GEOLOGICAL SURVEY BRANCH
DEPARTMENT OF MINES
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

REPORT OF ACTIVITIES FOR 1988

Compiled by
C.P.G. Pereira and D.G. Walsh

St. John's, Newfoundland
1988

91-02874/

The following projects, as numbered in the Table of Contents, are contributions to the **Canada-Newfoundland Subsidiary Agreement on Mineral Development, 1984-1989:**

1, 2, 3, 6, 7, 8, 9, 11, 16, 17, 18, 21, 22, 23, 26, 27, 28, 29, 30, 31, 34, 35, 36, 39, 41

The following projects were funded by the **Newfoundland Department of Mines** outside the Canada-Newfoundland Subsidiary Agreement:

4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 29, 30, 31, 32, 33, 37, 38, 40, 41, 42, 43, 44, 45

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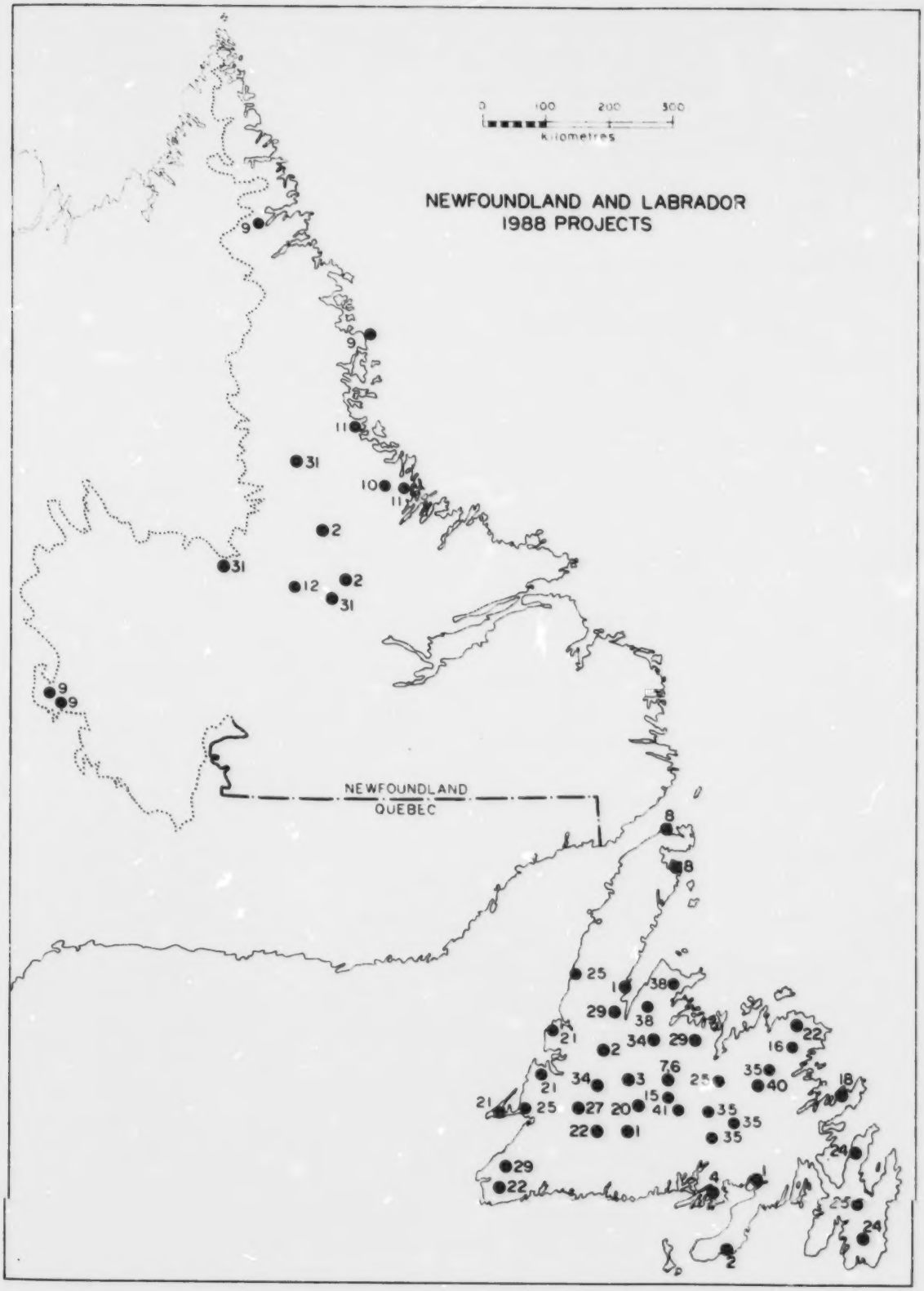
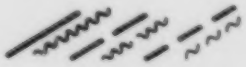

0 100 200 300
Kilometres
NEWFOUNDLAND AND LABRADOR
1988 PROJECTS
NEWFOUNDLAND
QUEBEC

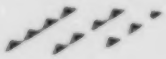
GEOLOGICAL MAP SYMBOLS

Geological contact (defined, approximate, assumed, gradational)

Fault (defined, approximate, assumed)



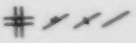
Thrust fault (defined, approximate, assumed)



Zone of numerous imbricate thrust faults

Bedding, tops known (horizontal, inclined, vertical, overturned)

Bedding, tops unknown (horizontal, inclined, vertical, dip unknown)



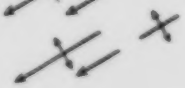
Pillow bedding, tops known (inclined, vertical)

Flow banding (inclined, vertical)

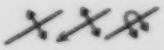
Fracture cleavage (inclined, vertical)

Syncline, showing direction of plunge (defined, approximate)

Anticline, showing direction of plunge (defined, approximate)



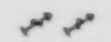
Antiform (horizontal, plunging, overturned)



Synform (horizontal, plunging, overturned)

Minor fold axis (with plunge)

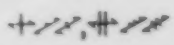
S-folds, Z-folds



Gneissic foliation (horizontal, inclined, vertical, dip unknown)

Schistosity, cleavage, foliation (horizontal, inclined, vertical)

S_1, S_2



Foliation due to thrusting (inclined, vertical)

Lineation, fold axis, mineral rodding

Jointing (horizontal, inclined, vertical)

Primary igneous layering (inclined)

Shear zone (approximate)

Alteration zone

Unconformity

Contact inferred from magnetic anomaly

Glacial striae

Drift covered area

Topographic lineaments from aerial photographs

Road

Power transmission line

Mine

Mineral Occurrence

Location of measured section

Abbreviations

Arsenopyrite	asp	Iron formation	i-f
Asbestos	asb	Magnetite	mag
Chalcopyrite	cp	Molybdenite	mo
Copper staining	cs	Pyrite	py
Fluorite	fl	Pyrrhotite	po
Galena	gn	Radioactive minerals	ra
Hematite	hem	Serpentine	sup
		Sphalerite	sp

Chemical symbols are used for elements, e.g. Cu.....copper.

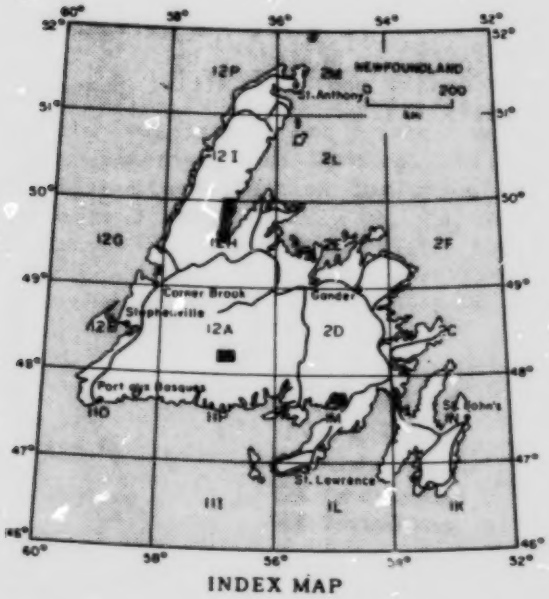
ECONOMIC GEOLOGY

GRANITE METALLOGENY PROJECT

by

J. Tuach* and C.M. Saunders**
*J. Tuach Geological Consultants Inc., **Mineral Deposits Section

During 1988, work on the Granite Metallogeny Project consisted of writing, interpretation of geochemical data, minor lab-work and photography. Emphasis was placed on the following three projects (Figure 1).



INDEX MAP

Figure 1: Project areas are outlined in black. From north to south - White Bay, Granite Lake, Cross Hills.

Cross Hills Intrusive Suite: The Cross Hills Intrusive Suite includes gabbro, biotite granite-aplite, and peralkaline granite. The latter is host to minor Zr, Y, Nb mineralization which is found in sheeted aplite veins. SEM work on mineralized peralkaline granite samples has revealed several interesting exotic minerals including thorium silicate (thorite?), thorium oxide, Y-Nb oxide (fergusonite?) and several unidentified REE, Zr, Y, Nb, Ti bearing minerals. These minerals are associated with hydrothermal zircon, which in places forms zoned botryoidal crystals. A draft of a report, complete with photographs and figures is in preparation for publication in 1989, by the Newfoundland Department of Mines.

White Bay Granites: Work in this area has focussed on gold mineralization hosted by the Apsy pluton, a late Proterozoic foliated tonalite-granodiorite which has been altered to a granite by mineralising fluids. Geochemical analyses indicate the mineralizing fluids were enriched in Na, K, CO_2, S, As, Au and to a lesser extent in Br, W and Sb. The mineralized samples are strongly depleted in Y and heavy REE, perhaps as a result of destruction of mafic minerals. A paper on this topic (Saunders and Tuach, 1988) was presented at the GAC/MAC/CSPG annual meeting in St. John's. A report on the granites of the western White Bay area is in preparation. This report will include data compiled on the Gull Lake intrusive suite (including the Devils Room granite) and the Coney Head complex. In addition, data collected on mineralization (mainly gold) hosted by volcanics and sediments in the vicinity of the Doucers Valley Fault Complex will be included.

Granite Lake: Wolframite, molybdenite and native bismuth are found in sheeted quartz, quartz-greisen and quartz-pegmatite veins in a 25 km2 area between Granite Lake and Meelpaeg Lake. Geochemical data indicate that the granitoid rocks were enriched in potassium during

hydrothermal alteration. Anomalously low concentrations of Ga, Y, La and Ce are interpreted to reflect pervasive depletion by hydrothermal fluids. Work has progressed towards a report which is currently in preparation. Final geochemical analyses were completed in early 1988 and interpretation is in progress. A report on the soil and rock geochemical signatures of W, Mo, Bi mineralization at Granite Lake (Tuach, 1988) was presented at the Prospecting in Areas of Glaciated Terrain Conference, in Halifax.

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1988: K-feldspathization, albitization and gold mineralization in granitoid rocks: The Rattling Brook alteration system, western White Bay. Geological Association of Canada, Annual Meeting, St. John's, 1988, Program with Abstracts, Volumm 13, page A109.

Tuach, J.
1988: Tungsten - molybdenum - bismuth in the Granite Lake - Meelpaeg Lake area, Newfoundland: Geochemical signatures in rock and soil. Proceedings of CIMM conference on Prospecting in Areas of Glaciated Terrain, Halifax. Edited by D.R. MacDonald and K.A. Mills, pages 531-551.

RARE METAL EXPLORATION TARGETS IN LABRADOR AND INSULAR NEWFOUNDLAND

by

R. Miller
Mineral Deposits Section

Introduction

The present study of the rare metal mineralization within the Strange Lake peralkaline granite, the Red Wine intrusive suite and the Letitia Lake Group (Miller, 1986, 1987) of Labrador (Figure 1) has resulted in the development of a metallogenic model, for these felsic peralkaline rock-hosted deposits. The model suggests that rare metal mineralization, in general (i.e., complex mineralization including one or more of Zr, Y, REE, Nb, Ta, Be), occurs in anorogenic high level peralkaline felsic intrusions and their near-vent extrusive equivalents (Miller, 1988).

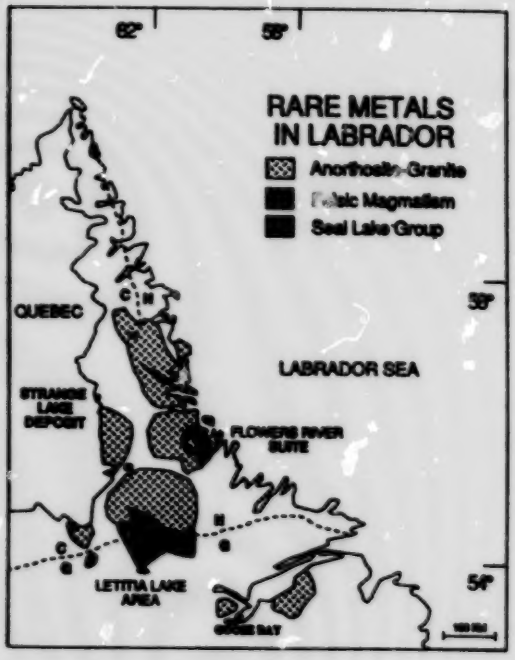

Figure 1: Location of felsic peralkaline plutons/complexes in Labrador: Strange Lake peralkaline complex, Flowers River igneous suite and the Letitia Lake area rocks.

Using the above model, the following geological settings have been identified in Labrador:

1) pegmatite-aplite dykes, and late stage roof zone phases in high level peralkaline granite plutons which did not vent to the surface (e.g., Strange Lake peralkaline granite),

2) pegmatite and pegmatite-aplite dykes, in the roof zone of vented peralkaline granites, and as disseminated mineralization in the near-vent extrusive equivalents (e.g., Flowers River igneous suite, Shallow Lake peralkaline granite),

3) subvolcanic veins associated with peralkaline quartz syenites, and as disseminated mineralization in the associated peralkaline trachytes, within the near-vent environment (e.g., Mann #1 and Two Tom Lake showings),

4) disseminated mineralization within high level undersaturated peralkaline complexes (Red Wine intrusive complex).

Settings number 1 and 3 (above) have been found to contain significant tonnages of high grade mineralization (Miller, 1988; Dujardin, 1961). High values of rare metals have been found in settings 2 and 4, although significant tonnages have not been outlined. These same settings have also

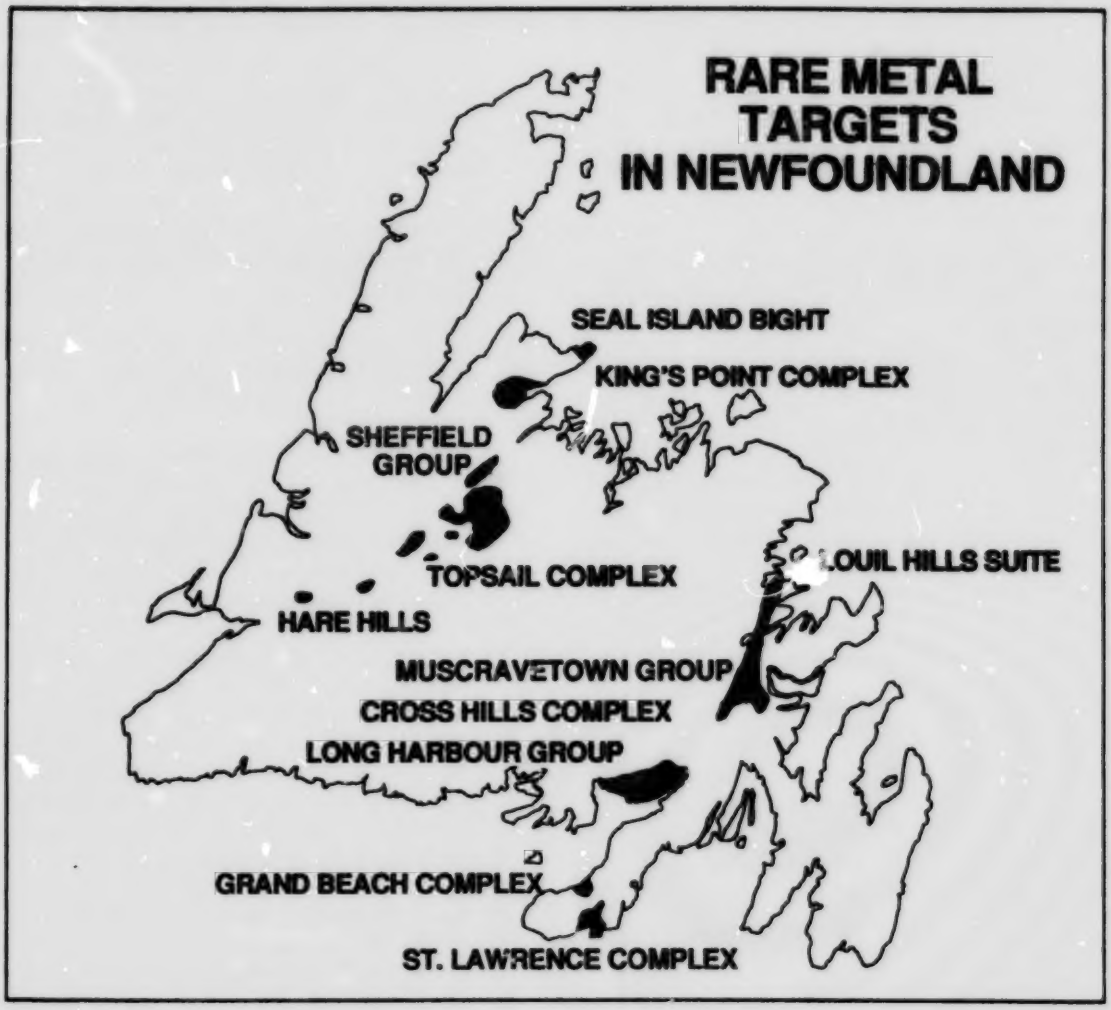

Figure 2: Peralkaline and related rocks in Newfoundland. Solid pattern indicates intrusive complexes and the shaded pattern indicates volcanic rocks.

been shown to contain significant rare metal mineralization elsewhere in Canada (Thor Lake, Northwest Territories, Trueman et al., 1985) and the world, (Saudi Arabi, Drysdale et al., 1984).

Insular Newfoundland

The rock types required in the settings for rare metal mineralization described above also occur in insular Newfoundland; thus general rare metal targets can easily be outlined. Obviously, any occurrence of felsic peralkaline rocks is a potential target. A preliminary survey of anorogenic and peralkaline volcanics and intrusions suggests that the complexes or suites listed in Table 1 are good rare metal targets (see Figure 2 for locations).

A compilation of previously published geochemical and other data is currently in progress to better evaluate these targets.

Table 1

RARE METAL TARGETS IN INSULAR NEWFOUNDLAND

Geologic Setting	Location	Plutonic Phase	Volcanic Phase
Setting #1	Grand Lake	Hare Hills per. granite	None identified
Setting #2,3	La Scie	Seal Is. Bight per. syenite	Cape St. John (non-per?)
Setting #2,3	Green Bay	Kings Point Complex (per±)	Kings Point Complex (per±)
Setting #2	Topsails	Topsails per. granite	Sheffield Group (per±)
Setting #1,2	Terra Nova	Louil Hill per. granite	Bull Arm Formation (per?)
Setting #1,2	Long Harbour	Cross Hills per. granite	Mooring Cove Formation (per?)
Setting #1,2	Burin	St. Lawrence per. granite	Rocky Ridge Complex
Setting #1,2	Burin	Grand Beach Complex (per±)	Clancey Pond Complex (per?)

per = peralkaline, per± = portions are peralkaline, per? = peralkaline nature unconfirmed

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1984: Rare element mineralization related to Precambrian alkali granites in the Arabian Shield. Economic Geology, Volume 79, pages 1366-1377.

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METALLOGENIC MAP OF THE CENTRAL MOBILE BELT, NEWFOUNDLAND

by

D.T.W. Evans
Mineral Deposits Section

A 1:500,000 scale, coloured, metallogenic map of the Central Mobile Belt is being compiled. This work, which was begun in May 1987 will be completed shortly. The map will illustrate only syngenetic mineralization, hosted by Iapetus-related Cambro-Ordovician and Silurian sequences.

The mineralization, which is dominantly volcanogenic sulphide related, is subdivided on the basis of tectonic setting into arc/rifted arc, ophiolite or non-ophiolitic/non-arc settings. Further subdivisions of the mineralization is done, on the basis of host rock characteristics i.e., rock type and geochemistry. These subdivisions along with the size of the occurrence will be reflected by variations in the size and shape of deposit symbols. Deposit statistics will be presented in a table format.

The host rock sequences, which encompass parts of the Humber, Dunnage and Gander zones, will be coloured to reflect rock type, geochemistry and tectonic setting. Tectonic setting will basically follow platformal, arc/rifted-arc and ophiolitic subdivisions. Younger sequences, whether intrusive, volcanic or sedimentary, will be exhibited by a variety of patterns.

A METALLOGENIC STUDY OF THE CONNAIGRE BAY GROUP, SOUTHERN NEWFOUNDLAND

by

W.A. Sears and C.F. O'Driscoll
Mineral Deposits Section

Introduction

Base metal occurrences have been reported for some time in the area of the southwestern Avalon Zone. The deposit at Frenchman Head was investigated by NALCO in 1964-65. Interest has recently been rekindled by the discovery of significant base metals at Winter Hill. The deposits occur within the Upper Precambrian Connaigre Bay Group and were sampled and studied during the summer of 1988. The Connaigre Bay Group is a volcanic-sedimentary sequence located at the southwestern corner of the Avalon Zone in Newfoundland (Figure 1). All the base-metal occurrences were examined, with emphasis being placed on the Winter Hill and Frenchman Head area.

Mineralization

Mineralization outside the Winter Hill and Frenchman Head areas consist mainly of massive to disseminated pyrite with minor chalcopyrite. Semi-massive to massive pyrite is usually banded parallel to local bedding. The bands are quite thin (millimetre to a few centimetres thick) and appear to be exhalative in origin. Chalcopyrite is generally found in all significant pyrite occurrences, but rarely exceeds 1-2% of the total sulphides. This type of mineralization is found primarily, near the stratigraphic top of the Tickle Point Formation which consists essentially of felsic flows and tuffs and minor mafic flows (Greene and O'Driscoll, 1976; O'Driscoll, 1977).

Mineralization at Winter Hill is mainly layered, massive to disseminated sulphides within a carbonate-calc-silicate lens. The lens is bound on either side by mafic tuffs which are intruded by felsic and mafic dykes and sills.

The sulphide mineralization is dominated by spalerite with lesser amounts of galena, pyrite, pyrrhotite and chalcopyrite. The layered, massive to semi-massive sulphides are found in the calc-silicate facies rocks, whereas disseminated sulphides are found in both the calc-silicate and carbonate facies rocks. Minor amounts of magnetite occur where felsic dykes (sills?) are in contact with calc-silicates.

Winter Hill East (WHE) and Winter Hill West (WHW) (Figure 1) contain only minor amounts (5%) of sulphides and are quite similar in appearance to the pyrite occurrences in the upper Tickle Point Formation.

All the Winter Hill showings occur in the lower Sam Head Formation which conformably overlies the Tickle Point Formation.

Frenchman Head (FH#1) is a base-metal occurrence containing mainly pyrite, sphalerite, galena and chalcopyrite with a combined percentage (of sphalerite, galena, and chalcopyrite), reaching up to 5%. Most of the mineralization is disseminated with a small section containing banded disseminated sulphides.

The sulphides are hosted in felsic rocks of the Tickle Point Formation but mafic to intermediate rocks are prevalent throughout the local area.

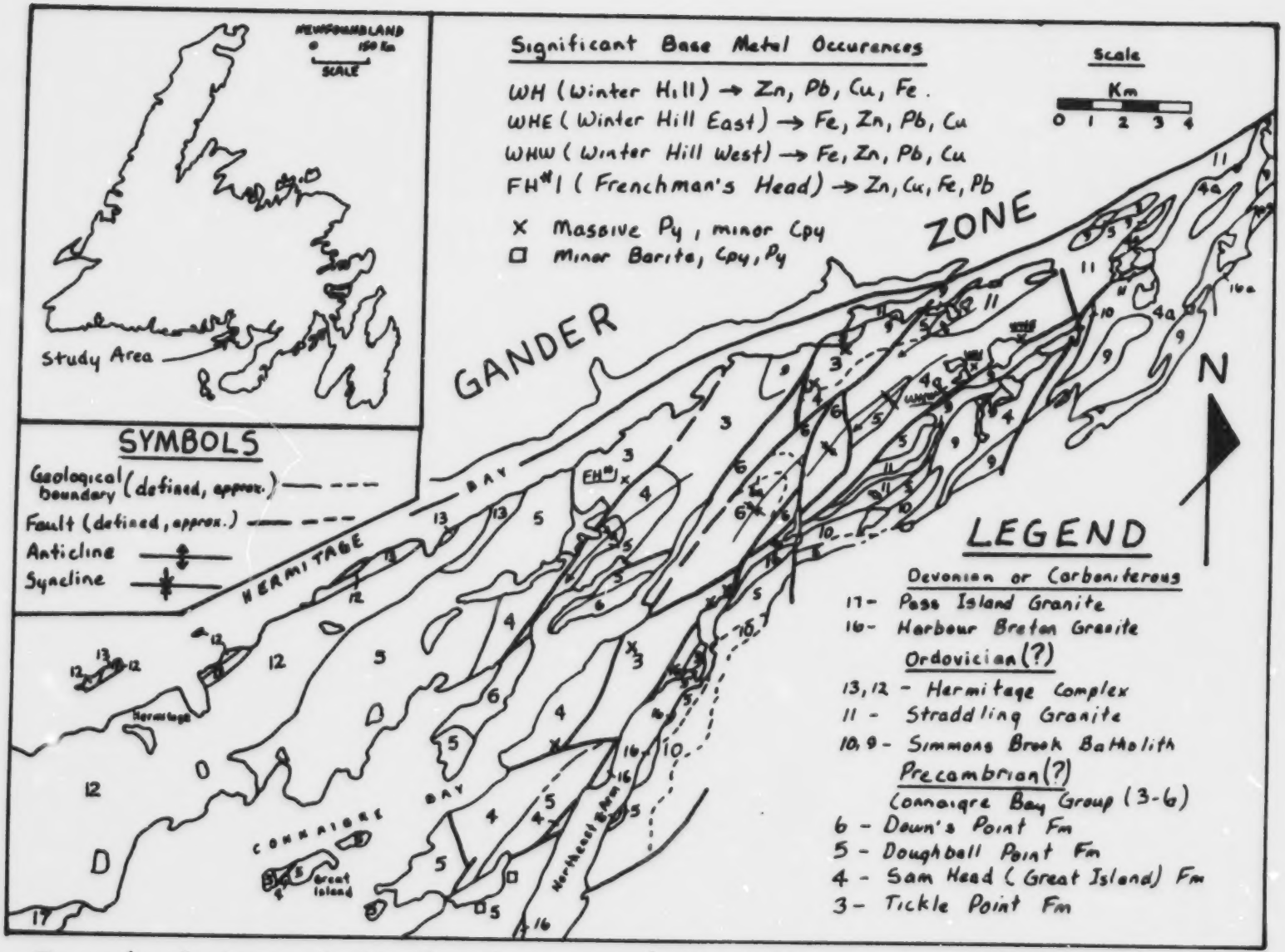

Figure 1. Geology of the Hermitage area. (After Greene and O'Driscoll, 1976.)

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1977: Geology, petrology and geochemistry of the Hermitage Peninsula, southern Newfoundland. Unpublished M.Sc. Thesis, Memorial University of Newfoundland, St. John's, Newfoundland.

MINERAL OCCURRENCE DATA SYSTEM

by

C.F. O'Driscoll, J. Smith and G. Stapleton
Mineral Deposits Section

The Mineral Occurrence Data System (MODS) is a two-part project, designed to offer an efficient information service of the known mineral occurrences in Newfoundland and Labrador. It consists of a manual Mineral Inventory File and a computerized Mineral Index.

The Mineral Inventory File is part of the National Mineral Inventory, and consists of mineral-occurrence descriptions, that summarize all data on known mineral occurrences in the province. The file contains approximately 3,500 descriptions including all mineral occurrences for the Island of Newfoundland (Figure 1) and selected areas in Labrador (Figure 2). The file and topographic location maps have been microfiched and duplicates are available on request.

Mineral-occurrence maps with updated geological bases, have been published at a 1:250,000 scale and are available upon request. In addition, selected areas have been published at 1:50,000 and 1:100,000 scales. These maps contain locations as well as a listing of the occurrences, including the name, status and minerals present.

The computerized Mineral Index contains information selectively extracted from the Mineral Inventory File. The purpose of the index is to organize important data so that a wide variety of retrievals can be made. Almost all of the index has been transferred from the Newfoundland and Labrador Computer Services (NLCS), where it previously resided, to the Division's computing facility. The file contains data on 3000 mineral occurrences in the province and can be accessed at the Department of Mines' offices in St. John's. Work is in progress to make it more accessible, either on floppy disks or by modem.

During the past year a questionnaire was circulated to mining and exploration personnel in an attempt to get some feed-back on the usefulness of the Mineral Occurrence Data System. We have received a good response and the results of the questionnaire are being tabulated. A review of the system will be undertaken and will incorporate all useful suggestions, made as a result of the questionnaire. In an attempt to expand the use of the system, it is intended to circulate the questionnarie to both academic and government personnel. If anyone should like to receive a copy, they may pick up one at the Open House, MODS display, or by contacting the Mineral Deposits Section. If you have one on your desk, dust it off, fill it out and send it back to us. Your comments are invaluable.

The manual Mineral Inventory File is used as a quick reference forspecific deposits. It is used daily by exploration company personnel and by government geoscientists. The file is available to anyone who is researching mineral deposits in the province.

By the use of computers, the retrieval capability from the computerized Mineral Index is optimized, and complex retrievals can be made that would be virtually impossible if a manual system were used.

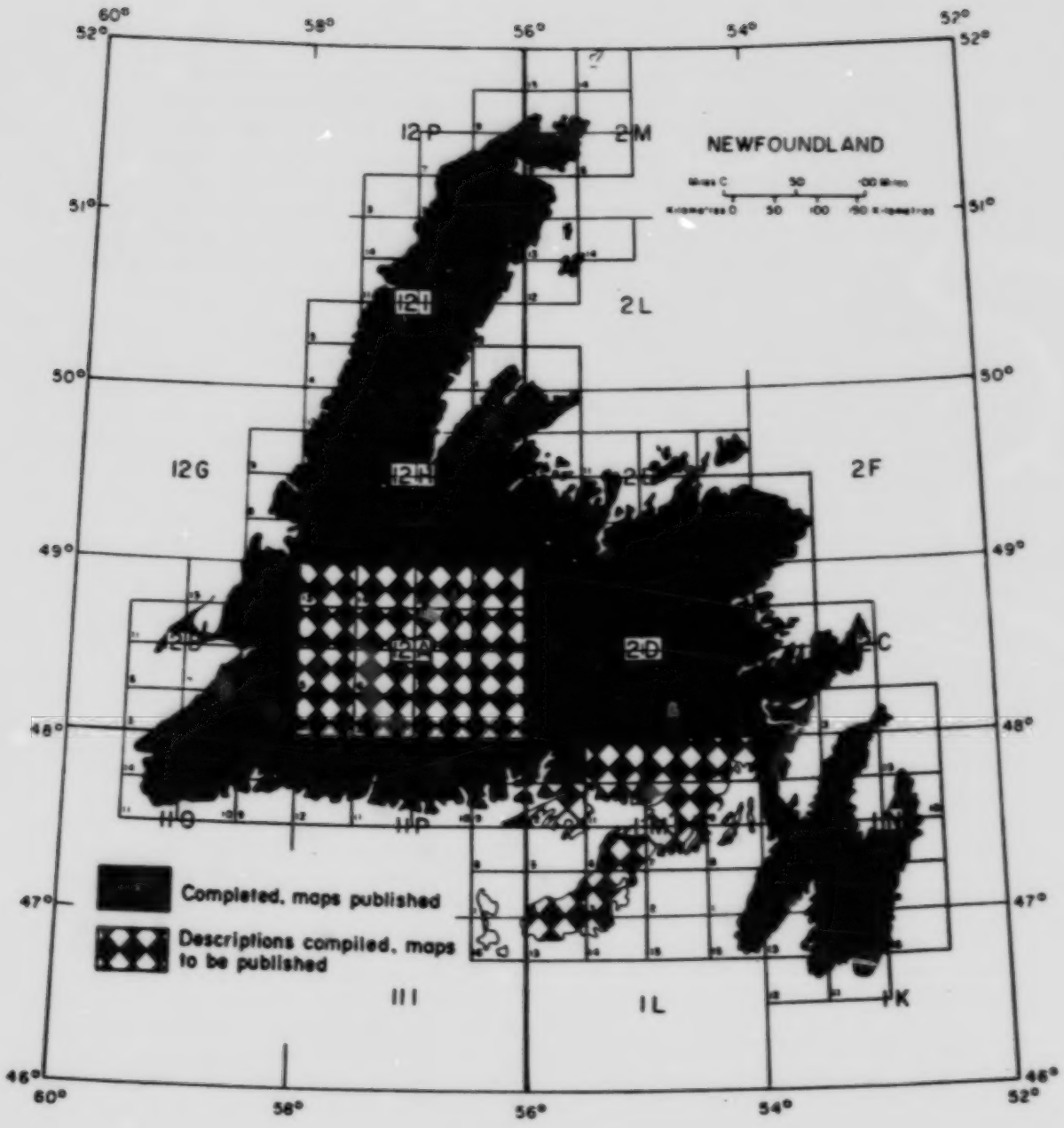

Figure 1. *Index map for Mineral Occurrence Data System project, insular Newfoundland.*

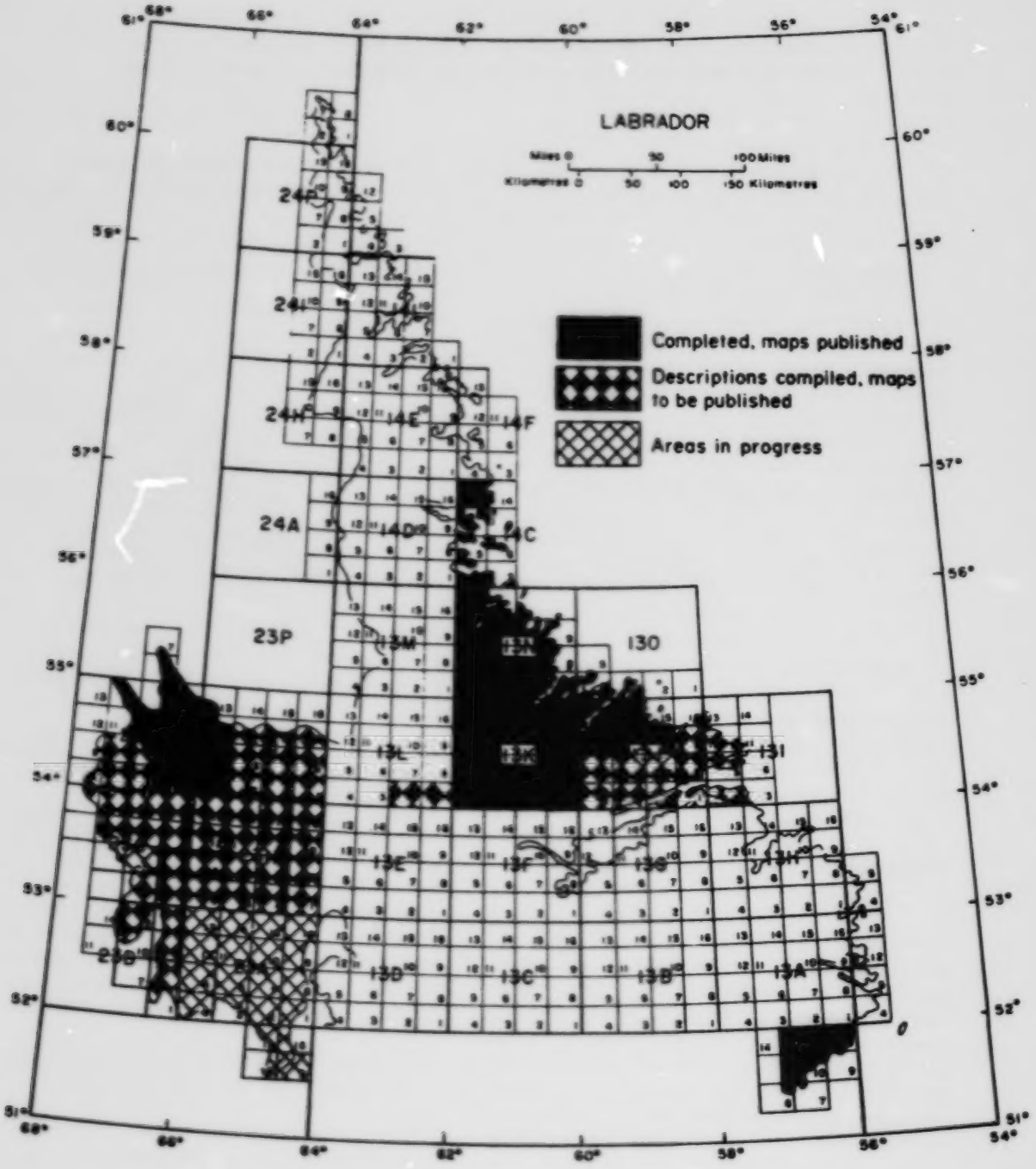

Figure 2. *Index map for Mineral Occurrence Data System project, Labrador.*

VOLCANIC ROCK GEOCHEMISTRY AS A GUIDE TO EXPLORATION FOR VOLCANOGENIC SULPHIDES: EXAMPLES FROM CENTRAL NEWFOUNDLAND

by

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Introduction

Regional metallogenic studies in central Newfoundland over the past several years have been directed towards identifying the paleotectonic settings of volcanogenic sulphide deposition. Detailed whole rock geochemistry, mineral analysis and isotope geochemistry of the host volcanic rocks have been used to interpret their petrogenetic history and paleotectonic settings (e.g., Swinden, 1987; Jenner et al., 1988; Kean and Evans, 1988; Swinden, 1988; Swinden et al., 1988). The objectives of the studies are to see, if there are consistencies in geochemical composition and/or paleotectonic setting of the host volcanic rocks, that can be used to focus regional exploration towards volcanic sequences of high potential.

Geochemical Signatures of Massive Sulphide Deposition

The vast majority of central Newfoundland volcanogenic sulphide deposits occur in rocks with a clear island – arc geochemical signature (Swinden et al., 1988). This is true of not only deposits in thick volcanic and sedimentary sequences traditionally interpreted as arc rocks, but also in some ophiolites (e.g., Betts Cove).

We have now, precise trace element data (including high field strength (HFSE) and Rare Earth Element (REE) for several of the most prolific volcanic sequences in central Newfoundland (Figure 1), and observe some regularities to the occurrence of volcanogenic sulphides, vis-a-vis, the affinities of the host rocks:

Figure 1: Location of volcanic sequences discussed in text (black). Stippled areas are remaining pre-Silurian volcanic and sedimentary remnants of Iapetus. BC - Betts Cove Complex; E - Exploits Group; LB - Lushs Bight Group; PH - Pacquet Harbour Group; VL - Victoria Lake Group; WB - Wild Bight Group.

1. **Wild Bight Group, central Notre Dame Bay:** Massive sulphide deposits, including the giant Point Leamington deposit, are uniquely associated with the combination of highly depleted island arc tholeiites and felsic volcanic rocks of trondhjemite composition (Swinden, 1987; 1988). All known occurrences of this combination

of volcanic rocks have associated volcanogenic sulphides. A similar setting is indicated for deposits in the adjacent Exploits Group, although the data is not as complete.

2. **Victoria Lake Group, south-central Newfoundland:** Massive sulphides in both Tulks Hill and Tally Pond volcanic belts are associated with mafic island-arc tholeiites (Kean and Evans, 1988; Swinden et al., unpublished data). Highly depleted mafic volcanic rocks similar to those in the Wild Bight Group are spatially associated with volcanogenic mineralization in the Tulks Belt and are clearly distinguished geochemically, from the incompatible-element enriched volcanic rocks in this belt, that have no associated mineralization. Similarly, incompatible-element depleted rocks have been identified in drill core, in the vicinity of the Duck Pond deposits in the Tally Pond belt, and are known in at least one area near Sandy Lake northeast of Tally Pond where a small massive sulphide prospect has recently been discovered (Kean and Evans, 1988).

3. **Lushs Bight Group:** The Lushs Bight Group consists of a complex sequence of mafic volcanic rocks with varying geochemical signatures (Jenner et al., 1988). However, massive sulphide deposits, including former producers at Colchester, Whalesback, Little Deer and Little Bay, are uniquely associated with extremely incompatible-element depleted mafic volcanic rocks, that are geochemically similar to boninites. These rocks are sufficiently distinctive geochemically, that their presence can be used to focus regional exploration for further deposits in the area.

4. **Betts Cove (ophiolite) complex:** Volcanogenic sulphides, including the Betts Cove and Tilt Cove deposits, are associated with highly magnesian, incompatible-element depleted, mafic volcanic rocks (Strong and Saunders, 1988) that were originally termed "basaltic komatiites" (Gale, 1973) and have more recently been shown to be similar to boninites (Coish et al., 1982; Swinden et al., unpublished data). These rocks, which carry an island-arc geochemical signature, are apparently overlain by barren volcanic sequences of the Snooks Arm Group which may represent a later oceanic island setting (Jenner and Fryer, 1980). The high potential host rocks are easily distinguished geochemically and their presence appears to be a favourable indication of exploration potential.

5. **The Pacquet Harbour Group:** Highly magnesian mafic volcanic rocks similar to those in the Betts Cove Complex (e.g., see Hibbard, 1983) host the Rambler deposits. The association with keratopyhric felsic volcanic rocks suggests a petrogenetic comparison with the Wild Bight Group. Tholeiitic basalts similar to those in the Snooks Arm Group overlie the boninites supporting a correlation with the Betts Cove Complex (Hibbard, 1983). The geochemical identification of these distinctive volcanic rocks provides a useful exploration tool in this area.

Conclusions

Most important massive sulphide deposits in central Newfoundland are hosted by volcanic sequences with an island-arc geochemical signature. A surprising number are intimately associated with mafic volcanic rocks that are highly incompatible-element depleted (including depleted arc-tholeiites and boninites). Deposition was apparently related to the extrusion of very hot magmas resulting from melting of refractory mantle sources. The geochemical composition of these rocks is sufficiently distinctive to constitute a regional exploration tool for volcanogenic base and precious sulphide deposits.

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METALLOGENIC STUDIES - CENTRAL NEWFOUNDLAND

by

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The central Newfoundland metallogenic studies project is now in the report preparation stage. The draft report on the geology and metallogeny of the Lushs Bight Group has been completed, and is presently being reviewed. The report on the metallogeny of the Victoria Lake Group has a projected completion date of March, 1990.

A number of associated and spin-off projects are also in progress. The regional metallogenic map for the pre-Middle Ordovician rocks of central Newfoundland, being compiled in conjunction with the Geological Survey of Canada, is reported on by the compiler, David Evans. The regional age dating program with Greg Dunning of the Department of Earth Sciences, Memorial University of Newfoundland is continuing and there is further work planned for 1989-1990. Work is also continuing on the study (M.Sc) of the Midas Pond gold prospect by David Evans. The use of volcanic rock geochemistry as a tool in volcanogenic massive sulphide exploration with examples from central Newfoundland is discussed by Swinden et al. (this volume).

INDUSTRIAL MINERAL ACTIVITIES ON THE GREAT NORTHERN PENINSULA

by

Ambrose F. Howse
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Late in 1987, the Government of Newfoundland and Labrador invited proposals for the development of two deposits of high purity white marble located near Roddickton on the Great Northern peninsula (Figure 1). The deposits were identified during the course of an assessment of the province's marble resources (Howse, 1986, 1987). The deposits, near Penny's Pond and Coles Pond occur in Lower Paleozoic carbonate platform rocks, within the Lower Ordovician St. George Group, where it has been deformed and metamorphosed in a series of thrust sheets beneath the Hare Bay allochthon (Knight, 1987). Diamond drilling delineated significant reserves of marble with a high degree of chemical purity and with brightness in the order of 96%, thus meeting the specifications for a number of industrial uses, including applications as filler in paint, plastic and paper. The proximity of the deposits to the deep harbours of Canada Bay, Conche, and Croque is a critical factor favourably influencing the commercial potential of the deposits. In 1987, new showings of high purity white marble were identified west of Croque (Howse, 1988) in a belt of Lower to mid-Ordovician carbonate rocks, informally referred to by Smyth (1971) as the White Arm Window. This area, in addition to the regions south of Coles Pond and Penney's Pond have become the focus of exploration programs by industry.

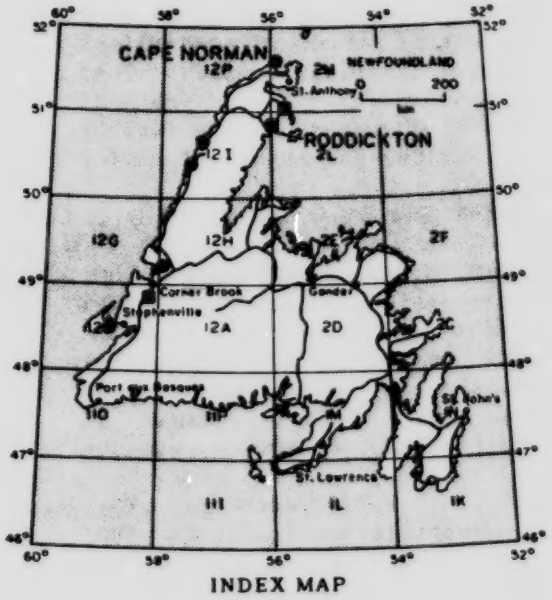

Figure 1: Location of study areas for marble ■ and dolomite ●

In August, 1988, the Government of Newfoundland and Labrador awarded the mineral rights to the Penny's Pond deposit to ECC America Incorporated and the Coles Pond deposit to Aurion Minerals Limited. Both of these companies had active exploration programs in the region during 1987 and 1988, and each had earlier submitted proposals to explore and develop the marble deposits.

Dolomite

In 1987, a study of the province's west coast dolomite resources was initiated with emphasis on deposits in the Lower Ordovician St. George Group (Delaney and Howse, 1988). The main objective was to identify deposits with a degree of purity, which would be suitable for magnesium extraction. Deposits in five major sites were mapped, and

sampled together with other occurrences. The major prospects are located on the Port au Port Peninsula, Goose Arm, Deer Cove, Port au Choix and Cape Norman. All samples from this survey have now been geochemically analyzed and the results are being assessed. The results will be published at a later date.

A report on the island's marble resources is currently being prepared for publication. This report will summarize all existing data and incorporate the results of the 1985-87 marble survey. A similar publication is planned when the dolomite project is completed.

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LABRADOR INDUSTRIAL MINERALS UPDATE

by

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*Mineral Deposits Section, **Mineral Resources Management Board

The 1988 field season in Labrador consisted of a week's follow-up work in Labrador West, and a two week reconnaissance survey of recently reported labradorite occurrences in the Davis Inlet area (Figure 1). Updates on existing and developing deposits are also reported.

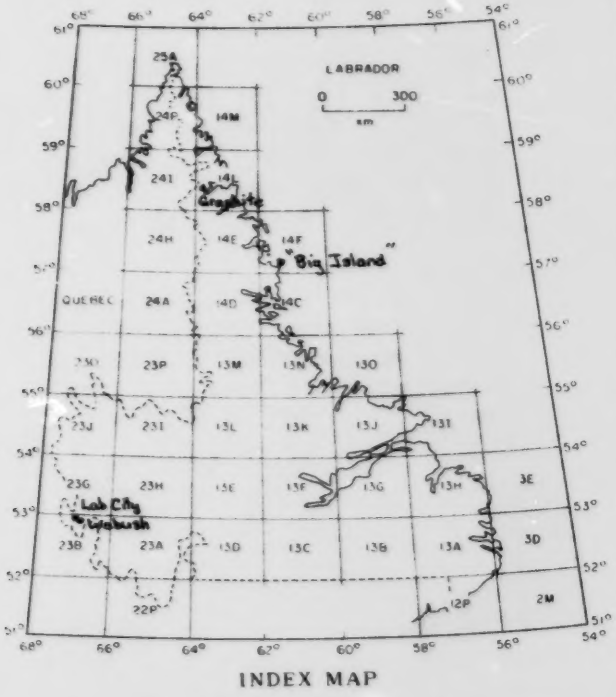

Figure 1: Index map showing areas surveyed during the 1988 field season.

Labrador West

Follow-up work was carried out on a kyanite-garnet-mica prospect at the south end of Flora Lake, 4 km south of the Wabush tailings area (Meyer and Dean, 1988). Initial laboratory examination of samples collected earlier, has been carried out by the Canada Centre for Mineral and Energy Technology (CANMET), and the results reveal the following: i) the kyanite crystals, which are up to 5 cm long, and make up to 20% of the prospect in selected zones, are generally free of impurities; ii) the garnet crystals, which are up to 1.5 cm in diameter and constitute up to 15% of the rock, are extensively embayed and intergrown with other minerals, and iii) the mica, dominantly muscovite, constitutes up to 15% of the rock but contains extensive fine inclusions of a black opaque mineral, possibly ilmenite or magnetite. Further testing is currently underway.

A pegmatite reported from the Trans-Labrador Highway (Meyer and Dean, 1988), 90 km east of Wabush, was visited and samples were collected. The exposure is approximately 5 m wide and consists of 5% to 10% muscovite, in books up to 10 cm by 15 cm, 50% to 60% white, striated feldspar crystals up to 8 cm in length, and 30% to 40% coarse crystalline quartz which is fractured and often stained with red hematite. The only accessory mineral observed was fine grained reddish garnet.

The Fermont Highway silica sand deposit, which was assessed through drilling in 1986 by a program funded under the Canada-Newfoundland Mineral Development Agreement, has been acquired by Blue River Mines of Calgary. The deposit is estimated to contain a minimum of 4 million tonnes of high purity friable quartz (Golder Associates, 1987). Processing studies

have been completed for a plant, with an initial design capacity of 60,000 tonnes per year, of high purity silica for glass markets. Market studies are being carried out for use of this silica in the solium silicate and filler industries as well.

A pre-feasibility study on the establishment of a "Silica-based Industry in Labrador West" was recently completed by Fenco Newfoundland Limited. The report indicates that the production of silicon metal, using local deposits of high purity quartzite, low cost hydro-electric power from Churchill Falls, and local infrastructure and manpower, could be very attractive and warrants a more detailed feasibility study. This report was funded under the current Canada-Newfoundland Mineral Development Agreement, and has helped generate additional interest in the high purity quartzite deposits in the Labrador City area.

A major summary report on silica resources in Labrador will be undertaken during the coming year. The report will include the Labrador West deposits (i.e., the Wishart and Sims Formations), veins and pegmatites samples in southeastern Labrador (Meyer and Dean, 1986, 1988), and chert deposits from the Ramah area.

A graphite deposit was sampled at the west end of Saglek Fiord in 1987, (Meyer and Dean, 1988). Representative samples from this deposit were analysed by CANMET and found to contain very pure graphite (80 to 83% carbon), with up to 5% quartz, minor amounts of garnet and micaceous minerals, and a trace of sulphides. The graphite has a crystal assemblage that is not easily delaminated, i.e., blocky grains with a low aspect ratio. The graphite prospect consists of a lense, with a maximum thickness of 90 cm, within a mylonitic quartz-feldspar-garnet gneiss. The potential exists for similar lenses at depth, below this exposed lense. Similar deposits of "lump" or "vein" graphite have been mined in Sri Lanka since the mid-1800's.

A new labradorite prospect was reported in the Davis Inlet area by Bert Saunders (a local fisherman) in the spring of 1988. This prospect was subsequently visited by one of the authors (E.M.) and based on the initial evaluation, a two week survey of the area was carried out in August, 1988. This prospect is outside of the areas which had previously been surveyed by the Department of Mines.

The prospect is on the southeastern coast of Tunungayualok Island (which is locally referred to as Big Island). It occurs within the anorthositic facies of the Nain Igneous complex, close to its southern border with older Archean Hopedale gneiss". The labradorite does not occur as megacrystic, interlocking crystals so typical of the pegamatitic pods in the Tabor Island - Kikkertavak Island area to the north. Instead, the best quality chatoyant labradorite in this area occurs as crystals "floating" in a groundmass of fine-grained, orange-white weathering feldspar (?). The crystals are subhedral to rounded, up to 30 cm in length, but more typically between 3 and 5 cm. The degree of chatoyancy is good, with colours including deep rich blue, tourquoise blue and green, and less commonly, greenish yellows. In several localities, colour zoned, hexagonal patterns were common. The rock type described above was informally referred to as an "intrusion breccia". It can be seen to intrude into medium to coarse grained grey anorthosite, as long narrow dykes, often with very sharp boundaries. In several exposures, however, the intrusion breccia was the dominant rock type, and contained rounded inclusions up to 1 m in diameter, of the non- or less chatoyant grey anorthosite.

The potential to quarry jewellery-grade labradorite from these prospects does not appear to be as feasible as in the pegmatitic pods, which are presently quarried at Tabor Island. It would require much larger volumes of rock to obtain equal amounts of labradorite, and the crystals obtained would not, in general, be large. However, at many of the prospects visited, there were moderate amounts of loose labradorite in the talus, which could be hand-picked. There is also potential for quarrying very attractive dimensional stone at several prospects, but the block size would generally be much less than 1 metre by 1 metre.

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REGIONAL GEOLOGY - LABRADOR

PRELIMINARY REPORT ON GEOLOGICAL MAPPING ALONG PART OF THE UGJOKTOK RIVER, CENTRAL LABRADOR. (NTS 13N/5 AND PARTS OF 13N/6 AND 13M/8)

by

A. Thomas and R.S. Morrison
Regional Mapping - Labrador

During the 1988 field season, geological mapping on a scale of 1:50,000 was carried out on NTS map sheet, area 13N/5 and the northern sections of maps 13N/6 and 13M/8 (Figure 1). The area is located along the southern boundary between the western Churchill and the eastern Nain structural provinces. The former is composed largely of Hudsonian gneissic and granitoid rocks, along with remnant Archean blocks that have undergone both the Kenoran and Hudsonian orogenies. The latter is dominated by Archean granitic gneisses, migmatites and metasediments which have been intruded by a series of Middle to Late Proterozoic, anorogenic granite and gabbro/anorthosite plutons (Taylor, 1971).

The oldest rock unit in the area is represented by tonalite amphibole ± pyroxene - biotite gneiss (Unit 1a) characterized by agmatitic zones, amphibolite pods and deformed diabase dykes. This gneiss occurs primarily in the eastern half of the map area and is typical of that found in the Archean Hopedale block of Ermanovics and Raudsepp (1979), and Ermanovics and Korstgard (1981). The tonalite gneiss has been intruded by a number of major Proterozoic anorogenic bodies including biotite - amphibole quartz monzonite to syenite (Unit 13), amphibole - pyroxene gabbro/anorthosite (Unit 12), quartz-feldsparporphyry (Unit 17) and peralkaline granite (Unit 18). In part, unconformably overlying the gneiss is a deformed supracrustal volcanosedimentary sequence, the Ingrid group (Unit 11) of Ermanovics and Korstgard (1981) (herein referred to as the Ingrid Lake group to conform with recommendations of the North American Commission on Stratigraphic Nomenclature, 1983). The northern margin is terminated abruptly by quartz monzonitic rocks of Unit 13.

In the northwestern part of the map area, crystalline basement is dominated by a series of mixed granitic and gneissic rocks, the two key lithologies of which are garnet-sillimanite, (hypersthene?), quartzofeldspathic paragneiss (Unit 3) and foliated to gneissic garnet-hypersthene porphyritic granodiorite (Unit 5). These gneisses and foliated intrusives are of probable Proterozoic (Aphebian) age, but may contain Archean components and appear to have been thrust over the Archean Hopedale block to the east. The nature of the contact is complex, but the immediate boundary between presumed Proterozoic paragneiss (Unit 3) and Archean tonalite gneiss (Unit 1a) is characterized by a zone of intense mylonitization, up to 500 m wide (Unit 1b).

The western and southwestern parts of the area are dominated by the Elsonian Harp Lake complex of Emslie (1980). The main unit exposed is a coarse grained porphyritic amphibole-bearing quartz monzonite (Unit 15), commonly exhibiting prominent rapakivi texture. This unit intrudes, both the main Harp Lake anorthosite body (Unit 14b), as well as its associated gabbronoritic rocks (Unit 14a). Rapakivi quartz monzonite, garnet-sillimanite paragneiss and porphyritic granodiorite have all been intruded by medium to coarse grained pyroxene- and amphibole-

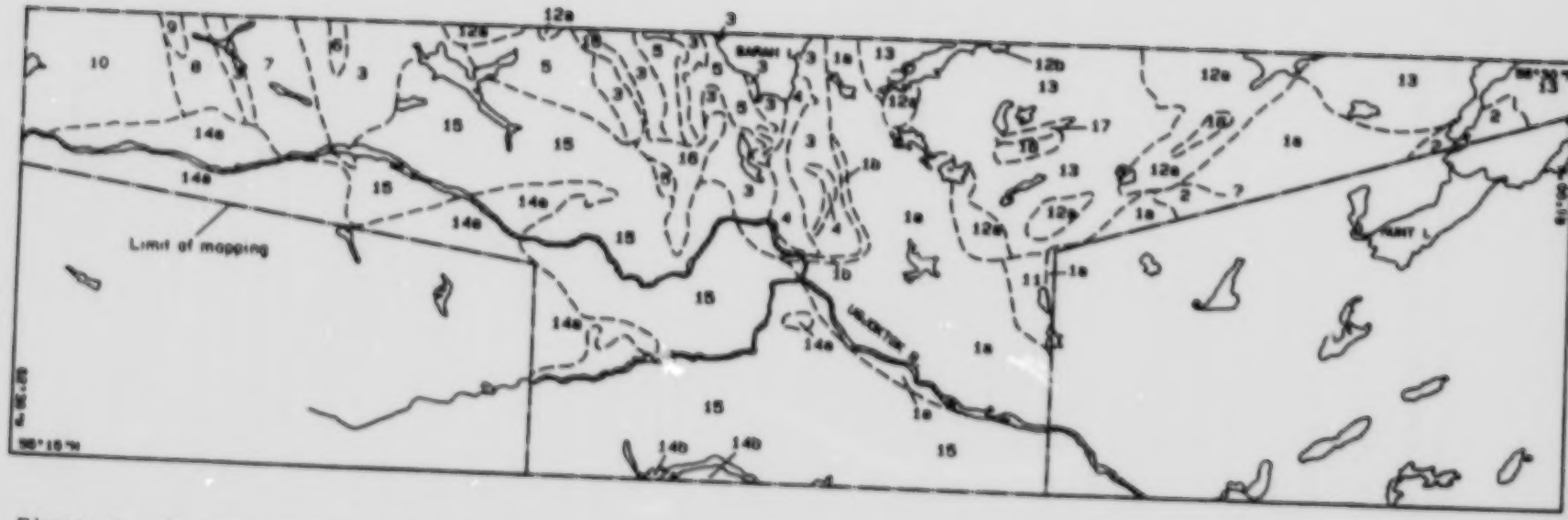

Figure 1. General geology along part of the Ugjoktok River, Central Labrador.

LEGEND

NEOHELIKIAN (Flowers River Igneous Suite)

18 Peralkaline granite

17 Quartz, feldspar porphyry

PALEOHELIKIAN

16 Pyroxene gabbro to pyroxene diabase

(Harp Lake Complex)

15 Monzonite, quartz monzonite (commonly rapakivi textured)

14 14a; Leucogabbro, gabbronorite, 14b; Anorthosite

(Nain Igneous Complex)

13 Monzonite, quartz monzonite, syenite

12 12a;Leucogabbro, gabbronorite,12b;Anorthosite

APHEBIAN (Ingrid Lake Group)

11 Mafic to intermediate volcanic rocks, conglomerate, siltstone,sandstone

APHEBIAN and/or ARCHEAN

10 Granitic orthogneiss

9 Foliated hornblende, pyroxene granite

8 Foliated biotite, amphibole diorite to monzodiorite

7 Granitic gneiss intermixed with tonalite gneiss and quartz syenite

6 Porphyritic granitic gneiss

5 Garnet, hypersthene porphyritic granodiorite

4 Quartz diorite, diorite

3 Garnet paragneiss with or without sillimanite

ARCHEAN

2 Foliated hornblende, biotite granite

1 1a; Tonalite orthogneiss, 1b; Mylonite gneiss

bearing gabbro/diabase (Unit 16), which occurs as either one or more subhorizontal sills capping these units. Small granite dykes noted within the gabbro indicate a further magmatic event, possibly associated with the emplacement of peralkaline granite.

The structural character of both the deformed granites and gneisses is dominated by a general north-south fabric. In the area immediately south of Sarah Lake, the garnet porphyroblastic quartzofeldspathic gneiss (Unit 3) displays an east-west gneissosity, which is crosscut by a series of north-south shears. Further east, the gneiss has been tightly folded, resulting in a secondary north-south gneissic fabric. The Archean tonalite gneiss (Unit 1a) becomes agmatitic towards the western contact (Unit 3). Here, disrupted lenses of amphibolite and banded tonalite gneiss are enclosed within a less strongly foliated quartzofeldspathic gneiss. Pegmatitic quartz-albite pods occur sporadically throughout this gneiss unit, and are considered to be associated with the last phase of deformation.

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THE EMPLACEMENT AND PETROGENESIS OF PROTEROZOIC DYKE SWARMS

by

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Introduction

The extent and magma volume involved in many Proterozoic dyke swarms has no Archean precedent or Phanerozoic analogue in Earth's history. Research suggests that such swarms were a result of an early attempt at fragmentation of the newly stabilized (previously permobile) Archean cratons. Examples of these swarms occur in Labrador, northwest Scotland and west Greenland, where they cut Archean gneisses of the North Atlantic craton. The Hopedale block in Labrador (Figures 1 and 2) was chosen for the study. This region affords excellent exposure and access by virtue of its coastal setting and lies within an area previously mapped by Ermanovics et al. (1984).

Geology

In order to separate regional and local variance in geochemistry, fieldwork involved detailed sampling of a limited area (Figure 2). Sampling of the margin and centre across the width of the dykes, was undertaken to plot magma evolution paths as the dyke dilated. Similarly, large dykes exposed for long distances were sampled along their length to test for geochemical evolution as the dyke propagated.

The evolution of the Hopedale block (Korstgård and Ermanovics, 1985) includes the intrusion of three dyke swarms; these are the Hopedale (age uncertain, but between 3100 and 2840 Ma, pers. comm., Ryan, 1988), the Kikkertavak (2200 Ma) and the Harp (1200 Ma) suites. The first is highly deformed, migmatized and metamorphosed at amphibolite facies, whereas the second and third swarms are undeformed and more suitable for petrogenetic study. Both the second (Kikkertavak) and the third (Harp) swarms are simple suites of olivine gabbro and dolerite, and are unlike many other Proterozoic dyke swarms (e.g., the Scourie dykes of northwest Scotland) which are complex.

Field outcrops indicate a north to northeast trend of intrusion, into the amphibolite facies gneisses (Korstgård and Ermanovics, 1985). The dolerites have a planar geometry, whereas the gabbros have a more irregular shape (Figure 3). This suggests emplacement of the latter into a more ductile crust due to either contact or regional effects. However, contacts of both rock types with the country rock are always discordant and sharp, with no assimilation haloes observed around xenoliths or at the margins. Furthermore, no disturbance of foliation or other plastic features were seen in the gneisses that could be accredited to intrusion of the dykes. It seems that the different outcrop patterns are due to the comparative ease with which the thinner dolerites could exploit small-scale anisotropies (e.g. foliation) in the gneisses. This does not explain the marked discordance to foliation, though dykes are often parallel to the regional Fiordian trend (northeast-southwest).

Contact effects in the country rocks were not observed, suggesting intrusion into a crust which was at moderate regional temperatures. Most intrusions, however, have a chilled

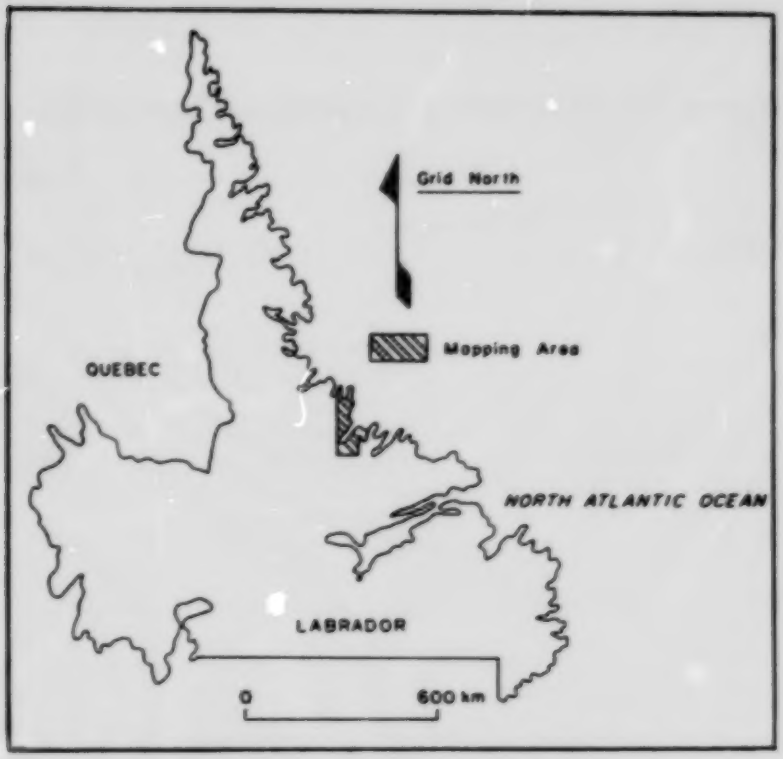

Figure 1: Map showing location of survey area.

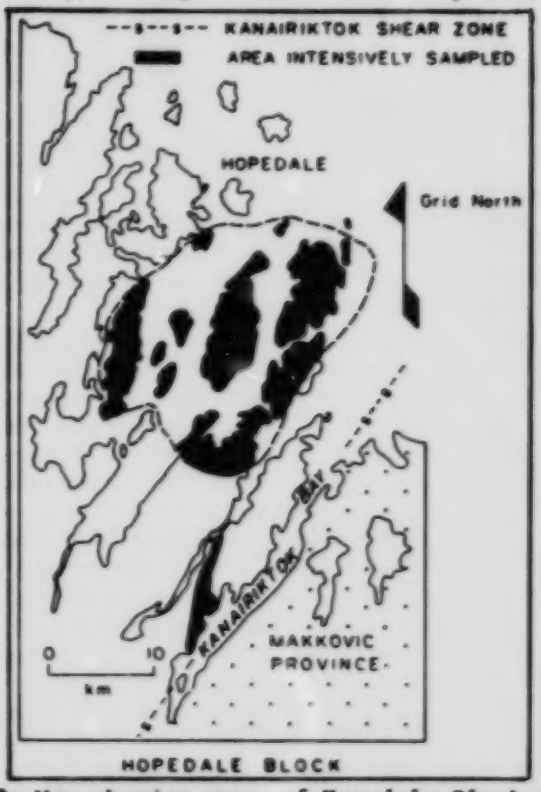

Figure 2: Map showing area of Hopedale Block which was extensively sampled.

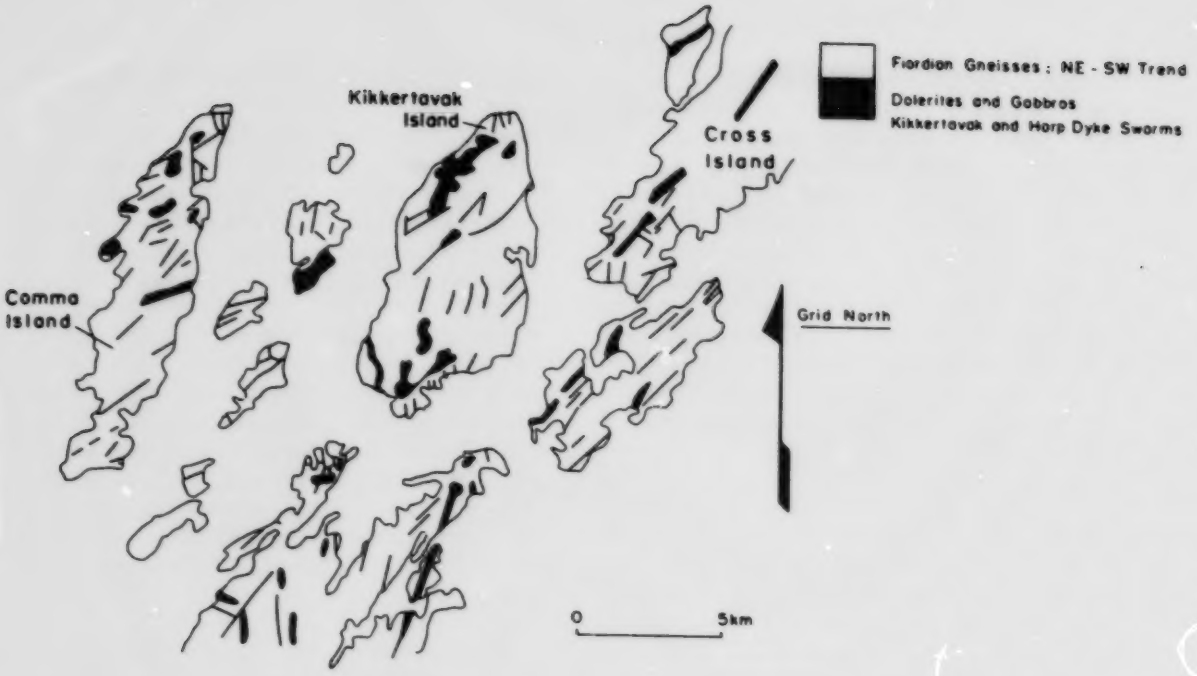

Figure 3: Cartoon map showing dyke trends in part of Hopedale block.

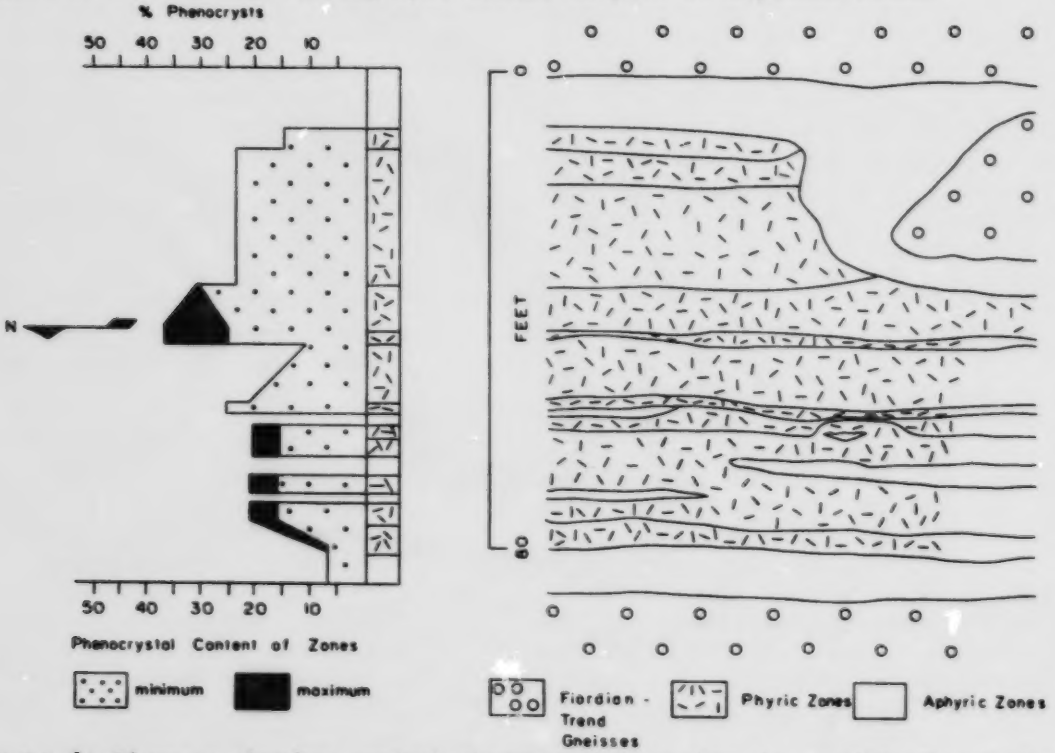

Figure 4: Diagram showing marked phenocrystal zoning in a Kikkertavak dyke, Cross Island.

margin, and the relatively fine grain size of the intrusions (dolerites 0.5-2 mm, gabbros 2-7 mm) appears to indicate a more rapid cooling. Therefore, it is likely that heat transfer was inefficient, and was by conduction rather than by convection. The lack of both thermal scavenging and crustal contamination is common in Proterozoic swarms (e.g. the Scourie dykes, Tarney and Weaver, 1987).

The Kikkertavak dolerites generally contain only minor olivine. Locally they are highly plagioclase phyric and all are slightly altered. Shearing of the Kikkertavak dyke margins is only present adjacent to the Kanairiktok shear zone, and then only on one margin. On the other hand, Harp dolerites are rich in olivine and are never plagioclase phyric or sheared. Hence, assignment of the dolerite dykes to their respective suites is easily accomplished both in the field and by petrology, but the gabbros are much more difficult to categorize. They consist of orthopyroxene, clinopyroxene, plagioclase and olivine. This assemblage was also seen in some pegmatitic lenses with crystals greater than 5 cm in length. The lenses are probably the result of a late stage process diagnostic of one suite only.

The porphyritic nature of some Kikkertavak dykes allowed accurate mapping of aphyric and phyric zones (Figure 4). Such changes are thought to be due to differing hydraulic conditions, (Platten and Watterson, 1987) rather than different magma types passing through the dyke as it dilated. Neither reabsorption of phenocrysts, nor intradyke chilled margins were seen, suggesting a continuous equilibrium process.

Lastly, emplacement of the dykes was dominated by dilational processes (necessary to avoid contamination), and only on one occasion was significant (50% xenolith content) stoping seen. Dilation was usually oblique (up to 30° from the orthogonal) to the dyke wall. Studies of dilation directions may yield different paleostress extension directions for the Kikkertavak and Harp suites.

Preliminary Conclusions

The Kikkertavak and Harp dyke swarms exhibit mineralogical differences, however, the degree of chemical overlap, if any, is unknown. Hence, some of the dykes, particularly the gabbros, may have to be dated to determine the suite to which they belong.

The large age difference between the two swarms, along with their respective trace element and isotope geochemistry, may provide information about crust-mantle interaction during the Proterozoic, particularly with regard to mantle depletion in large-ion-lithophile elements.

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(continued on page 125)

RECONNAISSANCE STUDIES IN THE SEAL - LETITIA LAKE AREA, LABRADOR

by

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Approximately two weeks were spent in the examination of well-exposed sections and known mineral occurrences in the Middle Proterozoic Letitia Lake and Seal Lake groups. This work was undertaken, partly as preparation for future Government mapping projects in the area, and partly as a reconnaissance examination of the precious-metal potential of the area.

The Letitia Lake Group (Brummer and Mann, 1961; Thomas,1981) consists mainly of quartz-feldspar-porphyry and felsic volcanic rocks. The north-eastern (uppermost ?) part of the group displays an hematite - sericite - magnetite alteration, which passes locally into dark porphyry-derived sediment and conglomerate. This has been interpreted by Marten (1975) and Thomas (1981) as a metamorphosed paleoweathered profile. Altered Letitia Lake Group rocks are overlain by basal quartzites of the Seal Lake Group. The remainder of the Seal Lake succession consists of red sandstones and shales, intercalated with voluminous basalt flows and diabase sills.

Several sulphide showings occur in the Letitia Lake Group (Figure 1). One occurrence (S - Figure 1) consists of massive to disseminated pyrite lenses, several tens of metres in length, within rhyolitic rocks. The other occurrences consist of disseminated pyrite, locally associated with minor galena and sphalerite, in quartz vein and stockwork systems. Sericitic alteration is present but is difficult to distinguish from the metamorphosed products of paleoweathering. One area of sulphide occurrences is associated with a spectacular boulder train (T - Figure 1) consisting of intensely altered

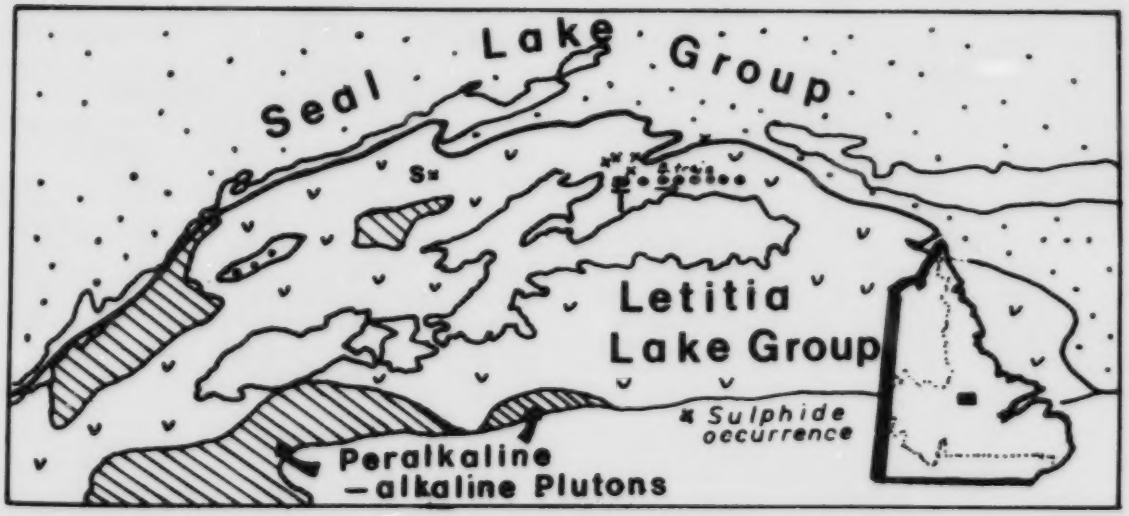

Figure 1: Map illustrating study area (see text for details).

(pyrite - sericite), rusty volcanic rock. A small sulphide showing exists near the head of the train but the extent and size of the boulders (up to 4m diameter) indicates a much larger source than presently exposed. Quartz - pyrite vein systems also cut nearby quartzites of the Seal Lake Group, indicating that the sulphide mineralization is part of a relatively late event.

Twenty-nine samples were assayed for Au, Ag and 32 other trace elements (excluding base metals). Samples consisted largely of Letitia Lake Group rocks, but also included some pyritiferous shales from the Seal Lake Group. Precious metal results were uniformly disappointing. However, it is believed that the boulder train and its source are worthy of further investigation.

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LABRADOR GEOCHRONOLOGY DATABASE

by

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Regional Mapping - Labrador

Scope and Objectives

Over the past two decades a significant number of radiometric age dating results have been collected. These results range from the very earliest K-Ar work carried out by the Geological Survey of Canada in the early 60's, to Rb-Sr, Sm-Nd and U-Pb work, presently being done in laboratories at several scientific institutions.

The validity of some of the older dates is questionable. However, to limit subjectivity, only those dates which are unrefutably accepted as incorrect, have been excluded from the database. All other dates have been included, with comments stating any restrictions as to their interpretation.

The main objective of the database project is to compile geochronological information into a database format. Beyond the ability to perform customised data searches, it is also intended to produce maps showing sample location, the isotope system used, and the determined age. This map(s) would be available as an overlay to the present 1:1,000,000 scale compilation map of Labrador.

Progress to Date

Database compilation and entry into the "Reflex" database management program are complete and current, with the exception of editing and compilation of individual records. The number of records input to date is 729. In the instance where an age dating method has produced an interpretative pair, each member of the pair (i.e., lower or upper - intercepts on a concordia diagram), are recorded as separate dates. Some duplication of records presently exists, but will be corrected as editing proceeds.

Each data record is supplied with a source reference for the purposes of cross-reference and confirmation of interpretation and usage.

A wide variety of criteria such as; NTS area, rock type, major lithologic unit, etc. may be used as search/sort criteria to isolate a data subset.

Some modification is required with the data presentation but the database manipulation is functionable. A subset of data is available for experimentation on its usefulness in graphical representation.

The database will be published in hard-copy form over the next few months. This will likely include sample location overlays suitable for use with existing geological compilation maps. The database will also be available on floppy disk, as either ASC-II text, or Reflex program files.

INDEX TO GOVERNMENT GEOLOGICAL MAPPING IN LABRADOR

by

L.V.J. Crisby
Regional Mapping - Labrador

Compilation of the Geological map index to systematic bedrock mapping in labrador, current to 1987, is now complete. The index is presently being drafted and is expected to be published shortly.

The Geological mapping of Labrador has been carried out by the Newfoundland Department of Mines, in co-operation with the Geological Survey of Canada since 1974, mainly at the 1:100,000 scale.

The last index to geological mapping in Labrador (Harris, 1977) consisted mostly of Industry and Geological Survey of Canada work. A decade of work since that compilation has resulted in a significant increase in the number of maps and reports, both published and unpublished. The present map index deals with only those maps and reports produced by the Newfoundland Department of Mines or the Geological Survey of Canada.

The new compilation shows the geological map areas covered by Newfoundland Department of Mines, (1:200,000 scale, and locally more detailed), and the Geological Survey of Canada, (1:125,000 scale to 1:100,000 scale and locally more detailed). Geographic areas are outlined on a 1:1,000,000 scale base map. Mapping done by the Geological Survey of Canada at 1:250,000 or less, is shown in an inset map.

The index, which is organized according to the National Topographic System, is intended as a reference tool to aid in the rapid search for publications on a geographic basis. In cases where reports or maps have been superceeded by a final more comprehensive report or map, only the latter is cited.

The Index shows 77 areas covered by Newfoundland Department of Mines maps and/or reports, and 70 areas covered by the Geological Survey of Canada, at a variety of scales.

Copies will be available from:

Newfoundland Department of Mines
Geological Survey Branch
Publications and Information Section
P.O. Box 4750
St. John's, Newfoudland
A1C 5T7

Reference

Harris, A. (comp.)
1977: Geological Map Index of Labrador. Mineral Development Division, Department of Mines and Energy, Government of Newfoundland and Labrador, Map 7714 (includes geological survey, industry and other sources).

REGIONAL GEOLOGY - NEWFOUNDLAND

GEOLOGICAL UPDATE OF THE MIGUELS LAKE MAP AREA, 2D/12, NEWFOUNDLAND

by

S. Colman-Sadd
Regional Mapping - Newfoundland

The Miguels Lake area was mapped at the 1:50,000 scale in 1981 (Colman-Sadd and Russell, 1981). Since then, major revisions have been made in the geological interpretation (Figure 1) and a new edition of the open file map of the area is now available (Colman-Sadd and Russell, 1988).

The revisions result from:

a) the dating of fossils from the Spruce Brook Formation as Middle Ordovician. This has made necessary a substantial reordering of the stratigraphy shown on the originally published map, and has also given rise to drastic reinterpretation of regional structural geology in central Newfoundland (Colman-Sadd and Swinden, 1984; Williams et al., 1988).

b) new access and new exposure created by logging operations in the northeast of the map area. The principal effect has been to expand the area known to be underlain by shallow water to subaerial clastic sediments of the Silurian Botwood Group. The major fault system southeast of Great Rattling Brook was previously only observed at Miguels Lake. Two more exposures of east-northeast trending faults have been discovered, in both of which, the Botwood Group is separated from the Spruce Brook Formation by sheared and brecciated zones of altered ultramafic rocks. The fault defined by these exposures coincides with a major aeromagnetic anomaly and, although parallel with the fault at Miguels Lake, is offset from it by about 1 km towards the northwest. The Botwood Group - Spruce Brook Formation contact is envisaged to have originally been a thrust fault that has been offset by the parallel east-northeast trending vertical faults, which extend well into the Botwood Group outcrop area. In the northeast corner of the map area, the edge of the Mount Peyton batholith has been exposed. This was not previously shown on the 1:50,000 map, and was depicted as gabbro on Hibbard's (1983) 1:1,000,000 map of Newfoundland. It is, in fact, grey, pink-weathering, feldspar-porphyritic granite.

c) U/Pb radiometric dating of tuff from the Stony Lake volcanic rocks. The age of the tuff is 423 ± 3 Ma (Dunning et al., 1988) corresponding to the mid-Silurian, and approximately equivalent to upper parts of the Botwood Group. The Stony Lake volcanics appear to lie with angular unconformity on folded and cleaved Botwood Group, so this date places tight constraints on the timing of major orogenic activity in the Newfoundland Appalachians.

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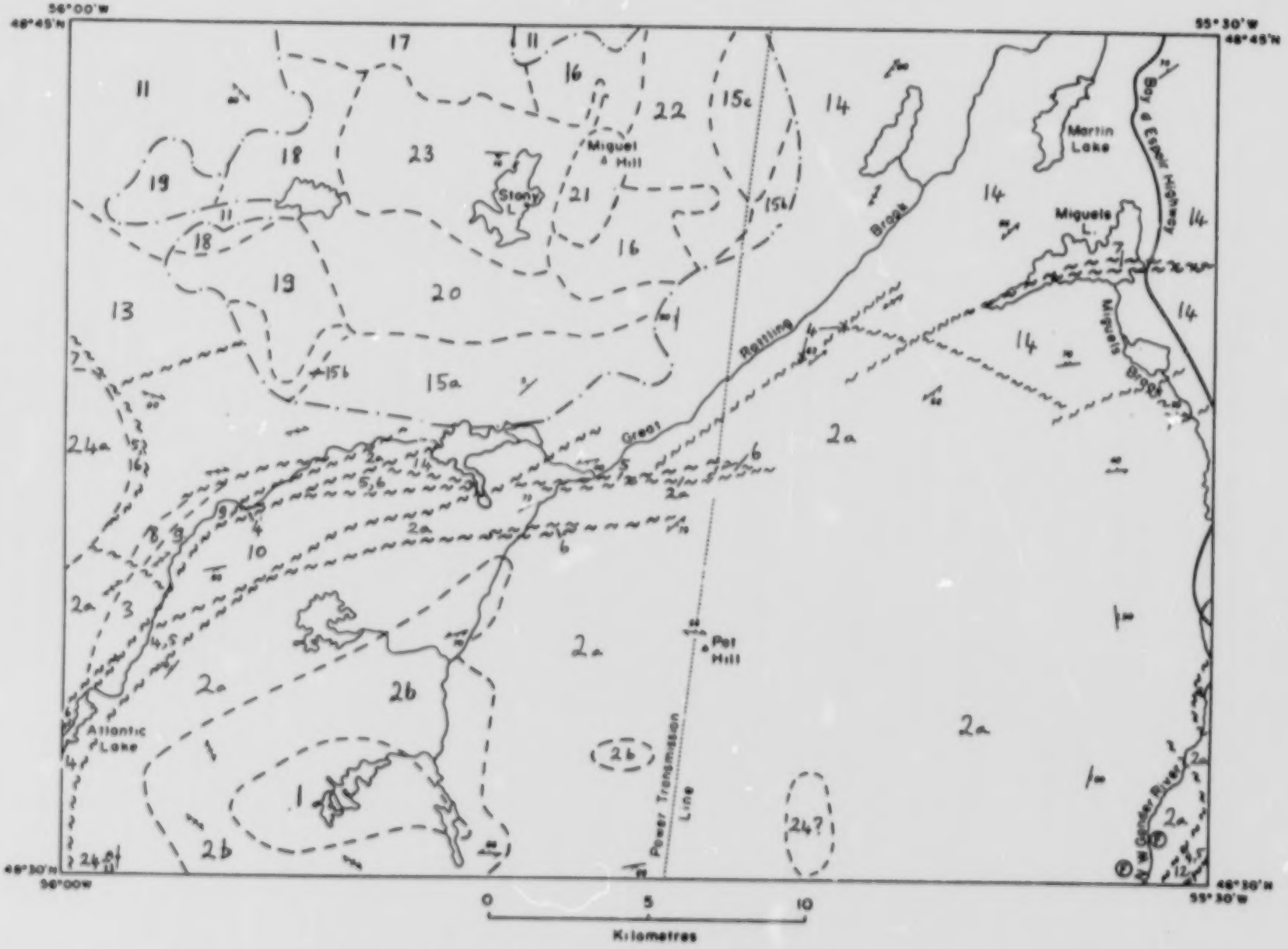

Figure I. Geological sketch map of the Miguels Lake Area

LEGEND

DEVONIAN OR OLDER

24 Garnetiferous biotite/muscovite granite; 24a, Overflow Pond Granite

SILURIAN

Stony Lake Volcanic Rocks

23 Dark grey to black feldsparphyric rhyodacite: Mainly pyroclastic, locally flow banded

22 Dark grey to dark green feldsparphyric rhyodacitic lapilli tuff

21 Grey and purple flow banded or brecciated rhyolite

20 Purple and pink rhyolite: Mainly pyroclastic, locally flow banded

19 Light purple, feldsparphyric rhyolite: Mainly pyroclastic, locally flow banded

18 Grey rhyolite: Mainly lapilli tuff, locally flow banded

17 Medium grained quartz and feldspar rhyolitic crystal tuff

16 Mainly buff, but locally green and purple, feldsparphyric, pyritiferous rhyolite: Mainly flow banded, but locally pyroclastic

15 Siltstone and sandstone: 15a, grey; 15b, red; 15c, grey and red with blocks of flow banded rhyolite and pyroclastic rocks

14 **Botwood Group**: Green-grey sandstone and siltstone with minor red siltstone beds

13 **Rogerson Lake Conglomerate**: Unexposed, extrapolated from outcrop in Noel Paul's Brook area

DUNNAGE ZONE

MIDDLE ORDOVICIAN AND OLDER

Victoria Lake - Baie d'Espoir Groups

12 **North Steady Pond Formation**: Unexposed, extrapolated from outcrop in Burnt Hill area

11 **Tally Pond Formation**: Interbedded felsic crystal tuff and lapilli tuff

10 **Salmon River Dam Formation(?)**: Interbedded purple-grey sandstone, siltstone and minor shale

Pipestone Pond - Great Bend Complexes, etc.

9 Black shale interbedded with fine grained sandstone

8 Conglomerate: Composed mainly of mafic volcanic clasts

7 Mafic pillow lava, breccia and tuff

6 Gabbro, with minor trondhjemite

5 Pyroxenite

4 Peridotite

GANDER ZONE

SILURIAN?

3 Strongly foliated granite

MIDDLE ORDOVICIAN AND OLDER

2 **Spruce Brook Formation:** 2a, Interbedded grey sandstone, siltstone and shale with minor conglomerate and limestone beds, metamorphosed in the greenschist and amphibolite facies; 2b, migmatite and granitoid gneiss thought to be derived from 2a.

1 Interbanded, migmatized, granitic, amphibolitic, semipelitic and psammitic gneisses.

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GEOLOGY OF THE WEIR'S POND (2E/1) MAP AREA

by

P. O'Neill
Regional Mapping - Newfoundland

The Weir's Pond map area, located northeast of Gander, provides a geological section across the contact of the Dunnage and Gander zones and through the western and central parts of the Gander Zone in northeastern Newfoundland.

The Dunnage Zone to the northwest, is represented by the Davidsville Group, which is herein formally divided into three formations: from east to west, the Weir's Pond, Hunt's Cove and Glenwood formations, respectively (O'Neill, in prep.). The Weir's Pond formation includes sedimentary units that are structurally imbricated with, and at least partly stratigraphically (nonconformably), overlying the Gander River complex (see below). The oldest unit within this formation is a sandstone of late Arenig age, containing abundant chromite, that may represent the earliest detritus from the Gander River complex.

It is proposed (O'Neill, in prep.) to amend the term Gander River Ultrabasic Belt (Jenness, 1954) to Gander River complex, thus avoiding the use of the term "ultrabasic", as i) ultrabasic (sensu strictu) rocks are not exposed, and ii) the ultramafic rocks do not form a major portion of the complex. The Gander River complex, however, will include all igneous rocks previously assigned to the Gander River Ultrabasic Belt.

Although the Davidsville Group and the Gander River complex are structurally imbricated in a complex zone up to 7 km wide, the contact on the eastern side between the Gander River complex and the Gander Group is abrupt, and structural interleaving is not apparent at this scale of mapping. Much of the central and eastern parts of the Weir's Pond map area is underlain by the Gander Group, which is formally subdivided into two formations (O'Neill, in prep.), the Jonathans Pond and Indian Bay Big Pond formations. The term Indian Bay Big Pond formation is informally proposed to replace the older term Indian Bay formation used by Wonderley and Neuman (1984), as Indian Bay is approximately 15 km to the east, and much of this formation is actually exposed on the shores of Indian Bay Big Pond. The Jonathans Pond and Indian Bay Big Pond formations are stratigraphically continuous, at least locally; however, some contacts are obscured by structural high-strain zones.

The rocks of the Gander Group record a low to medium-pressure metamorphic facies series centred on the Ocean Pond Pluton - a leucocratic muscovite, garnet, tourmaline granite to the north. Biotite, garnet, staurolite, andalusite and sillimanite isograds are elongated northeastward in the central part of the area but are oriented southward to parallel the margin of the megacrystic, biotite-rich Deadmans Bay Granite. Cordierite occurs sporadically and only adjacent to this granite. Coarse grained muscovite porphyroblasts and a general hornfelsing are features associated with the aureole of the granite. The Deadmans Bay Granite is post-tectonic and intrudes previously metamorphosed sedimentary rocks.

North of Indian Bay Pond, a 500-m-wide and several-km long sliver

of ultramafic and gabbroic rock is structurally intercalated with sedimentary rocks of the Jonathans Pond formation. The rocks are completely metamorphosed to low-grade assemblages, compatible with the metamorphic grade in the surrounding metasedimentary rocks.

In terms of economic mineralization, the most interesting rocks are those within the Indian Bay Big Pond formation. A grab sample of felsic volcanic or partly silicified psammitic rock, taken south of Southern Pond in 1987, assayed 2200 ppb gold. In August 1988, a lake sediment geochemical release from the Newfoundland Department of Mines also targeted the same area for gold. Several companies now hold properties in the area.

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SILURIAN OROGENY IN SOUTH-CENTRAL NEWFOUNDLAND

by

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*MUN Earth Sciences, **NF Department of Mines, +Royal Ontario Museum

Recent mapping and petrological studies within the Hermitage Flexure and parts of the south-central Dunnage Zone, combined with precision U/Pb geochronology, provide new insights into the evolution of the Central Mobile Belt. This has resulted in the identification of an extensive but short-lived Silurian orogenic event, which is separable from the classical Early Devonian Acadian Orogeny.

The Bay du Nord Group, which defines the map pattern of the Hermitage Flexure, is dated at 466 ± 3 Ma, coeval with some major middle Ordovician volcanic units, elsewhere in the Dunnage Zone. This date provides the lower age limit for the main Paleozoic deformational event recognized in the Hermitage Flexure. The subaerial, largely felsic volcanic La Poile Group, which lies to the south of the Bay du Nord Group, is dated at three localities as 420 +8/-2 Ma, 424 +7/-3 Ma and 428 ± 5 Ma. It is, therefore, Silurian over much of its presently defined extent, and is approximately coeval with the previously dated La Poile Batholith.

Two granitoid intrusions within the Burgeo Intrusive Suite, a large polyphase batholith that dominates the central Hermitage Flexure, yield zircon ages of 429 +5/-3 Ma and 415 ± 2 Ma. Confirming the composite nature of the pluton, these ages not only demonstrate the Silurian age of much of the suite but also brackets the D_1 regional deformation of the Bay du Nord Group.

The high grade Port aux Basques gneiss complex and the migmatitic Little Passage Gneiss, two major metamorphic complexes that are exposed at opposite ends of the Hermitage Flexure, yield U/Pb ages of 412 ± 2 Ma (titanite) and 423 +5/-2 (zircon), respectively. The Gaultois Granite, crystallized at 422 ± 2 Ma and with the Little Passage Gneiss crystallized through titanite blocking temperature at 417 ± 2 Ma. The post-tectonic (wrt D_1 of the Bay du Nord) North Bay Granite is dated at 396 +6/-3 Ma, providing an independent younger limit for the major Paleozoic deformational event in the flexure.

Evidence also exists for widespread Silurian activity north of the Hermitage Flexure, in the south-central part of the Dunnage Zone. The Main Gut and Boogie Lake gabbro-diorite intrusions yield U/Pb zircon ages of 431 ± 2 Ma and 435 +6/-3 Ma, approximately coeval with the earliest known pluton in the Burgeo Intrusive Suite. The Boogie Lake body shed detritus into a redbed-volcanic sequence that is dated at 429 +7/-3 Ma. Undeformed subaerial rhyolites of the Stony Lake volcanics, which appear to rest unconformably on folded and cleaved Silurian Botwood Group, are dated at 423 +3/-2 Ma. This apparently brackets an early Silurian deformation, which is probably coeval with the penetrative D_1 deformation bracketed in the Burgeo Intrusive Suite.

The contemporaneous emplacement of batholiths, high grade regional metamorphism and penetrative deformation, and widespread voluminous subaerial volcanic activity argues for a climactic Silurian orogeny

along the Hermitage Flexure, the effects of which are evident throughout south-central Newfoundland. This event is recorded by the Salinic unconformity in the Gaspe-Temiscouata Basin of Quebec, and can be correlated with high grade Silurian metamorphism and magmatism elsewhere in the Northern Appalachians (e.g., Cape Breton Island) and fall within the time frame of the Caledonian Orogeny in Scotland (coeval with the "newer granites"). Also, the ages from Newfoundland closely match ages of plutons and metamorphic rocks formed during the Scandian Orogeny in Norway.

STRATIGRAPHY AND SEDIMENTOLOGY OF THE CONNECTING POINT GROUP AND RELATED ROCKS OF BONAVISTA BAY, NEWFOUNDLAND: AN EXAMPLE OF A LATE PRECAMBRIAN AVALONIAN BASIN

by

Ian Knight, Sean J. O'Brien and Tomasz Dec
Regional Mapping - Newfoundland

In 1986, the Geological Branch initiated a detailed study of the stratigraphy of the Late Precambrian Connecting Point Group, as part of a larger regional mapping project of the Avalonian rocks of the Bonavista Bay region. The aims of the project include the establishment of a regional stratigraphy for the group, and to decipher its paleogeographic setting. Ultimately, the project will be expanded to include comparison and contrast of the provenance, and the overall evolution of the Avalonian basins of Newfoundland. Further, the depositional history of the basins will provide important insights into the tectonic setting of the Avalon Zone.

The work, to date has focused on the lower half of the group and has involved extensive regional mapping together with detailed logging of sections, along the shores of several of the many islands west and northwest of Burnside. Work on this project in 1988, has involved detailed petrography, a brief field reconnaissance of the higher stratigraphic sequences of the group, and a brief overview of the sections along strike to the south, with the aim of locating suitable sites for further detailed work.

In the Eastport-Salvage area, the Connecting Point Group forms an extensive succession, at least 3500 m thick, which is dominated by turbiditic sandstone, siltstone, shale and silicified sediment. At its base, is the Love Cove Group of mainly volcanic origin. The Connecting Point Group is unconformably overlain by the dominantly subaerial volcanic-sedimentary Late Precambrian Musgravetown Group. Six lithostratigraphic units and ten lithofacies are recognized; these formed in basinal and slope settings, prograding fan lobes and channel-levee complexes of submarine fans.

The basin fill comprises two, thick packages of turbidites, separated by mass flow deposits and pelagic deposits. The lower sequence, derived by erosion of a silicic volcanic source, is at least 2400 m thick. Initially, pyroclastic sediments and pelagic muds were deposited; at this time significant remobilization of volcanic material occurred and hydrothermal alteration was widespread. Subsequent deposition was mainly of sandy turbidite, again of volcanic provenance. This part of the lower succession coarsens upwards overall but consists of two distinct parts: i) a lower sequence deposited on a low-efficiency fan and typified by Ta sandy turbidites and the lack of either Bouma sequences or coarsening-upward and fining-upward sequences, and ii) an upper sequence deposited on the levee-channel complexes of channelled inner fans. The low efficiency submarine fan of the lower sequence suggests the basin at this time was small, with restricted configuration, steep slopes and narrow shelf. The subsequent development of a levee-channel complex reflects a more efficient fan, basin enlargement and more gentle slopes.

The mass flow deposits are associated with up to 600 m of pelagic and semipelagic slope

deposits, that contain a significant sand component. This part of the succession is characterised by numerous slump folds, breccias and slump scars and the presence of syn-sedimentary dykes. The mass flow deposits or mixtites contain olistoliths of shale, interbedded sandstone and shale, thin bedded siltstone and chert together with volcanic and plutonic clasts in variable proportion. Typically, the matrix is a pebbly mudstone with a significant tuffaceous component. The mixtite has a sharp, locally eroded base. The introduction of mass flows into the basin, together with the onset of syn-sedimentary plutonism and the influx of coarse volcanic detritus into the basin (indicative of the uplift of a volcanic source), suggest an episode of basin growth.

The succession above the mixtite is typified by silicified, classical turbidites arranged in coarsening- and thickening-upward sequences of shales and classical turbidites. Their presence suggest the existence of well developed, prograding submarine fan lobes. This part of the group is at least 1000 m thick at Salvage; however, its total thickness may be well in excess of 2400 m.

Only a few autochthonous fine grained tuff beds occur in the succession, and the coarse grained rocks of the group display no unequivocal evidence of welding. This suggests that the volcaniclastic rocks are the result of remobilization, mixing and deposition of pre-existing, arc-derived, pyroclastic and epiclastic sediments and not pyroclastic flows.

The detritus in the succession is characterised by two distinctive groups of predominantly andesitic and silicic volcanogenic material. Lithic and crystal tuff detritus of rhyolitic to dacitic composition dominates through most of the succession. Andesitic detritus, mainly pyroclastic lithic fragments, is also present through the entire sequence but predominates in and about the mixtites. It includes hypocrystalline, vesicular clasts with quenched plagioclase crystals, commonly with a trachytic arrangement and holo- to hypocrystalline, commonly trachytic, volcanic to subvolcanic fragments. Fragments of trachyte, diorite, microdiorite, granite, schist and quartz arenite are minor or trace constituents in the volcaniclastic succession. Intrabasinal, fine, tuffaceous detritus occurs in variable proportions throughout the entire succession.

The Eastport Basin lay adjacent to a volcanic arc, remnants of which may be preserved in the calc-alkaline Love Cove Group. It is probable, based on the petrography, that most of the pyroclastic material originated from subaerial and/or shallow marine eruptive centres.

The succession of the Eastport basin bears similarities to modern marginal arc basins. The lower part of the Connecting Point Group and the uppermost levels of the underlying Love Cove Group are analogous to the pelagic muds, pyroclastic rocks and mass flow epiclastic rocks characteristic of initial rift phase sedimentation in island arcs. Like the modern analogue, the base of the Eastport Basin succession has been affected by widespread hydrothermal alteration (see O'Brien and Knight, 1988, for description of alteration zones and assay results). The sandstone turbidites, deposited initially on a low-efficiency fan that subsequently improved its efficiency, suggest that a small, steep-sided basin widened and developed less precipitous slopes with time. The dominance of pelagic sediments in the overlying 1.5 km of the basin fill partly corresponds to the mature stage of modern arc basin evolution. However, the syn-sedimentary dyking,

the tuffaceous nature of the matrix of the mass flow deposits, and the transition upwards within the basin fill into classical turbidites, deposited on prograding deep-water fans indicate an interruption of basin maturation. At this time, the basin was affected by renewed extension and received detritus from a source terrane that may or may not have been the same as that which provided the bulk of the older basin fill.

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GOLD MINERALIZATION AND IGNEOUS ACTIVITY IN RELATION TO SYNMETAMORPHIC FOLDING, THRUSTING AND WRENCHING: A GENERAL MODEL FOR THE SOUTHEASTERN MARGIN OF THE CANADIAN APPALACHIANS

by

Brian H. O'Brien
Regional Mapping - Newfoundland

An important class of Atlantic Canadian gold deposits, including BP-Selco's Hope Brook Mine in Newfoundland, Western Mining's Forest Hill Mine and Beaver Dam Mine in Nova Scotia and the Gordex Mine at Cape Spencer, New Brunswick, occur near regional lineaments in Paleozoic rocks of the Appalachian Orogen. Most of these lineaments reflect ductile fault systems or tightly braided mylonite zones, the most significant of which record a protracted history of displacement and evidence of persistently high heat flow. Economically significant lineaments are characterized by (i) their common location above Precambrian or Cambro-Ordovician ancestral structures, (ii) repeated volcanism and plutonism along the fault lineament, (iii) polymetamorphism of some or all of the gold-bearing rocks near the fault lineament, and (iv) post-Devonian fault reactivation and lineament enhancement.

Regional Setting of Lineaments

Within the accreted, southeastern margin of the Appalachian Orogen, tectonostratigraphic terranes are commonly bound by large scale transcurrent faults or dextral megashears that delimit wrench fault systems varying between 103-105 km2 in area. The principal shear planes or east-trending master faults initially formed at a relatively late stage in Acadian (Siluro-Devonian) regional deformation; however, many developed near older faults or were ductilely reactivated by Hercynian (Carboniferous) movements. Orogenic flexures or megakinks were produced where wrench-generated, northeast-trending, Acadian-aged folds, foliations and thrust faults were rotated, along with pre-existing structures toward the ductile master faults. In Appalachian terranes, governed by either Acadian or Hercynian wrench faulting, the regionally predominant periclinal folds, and slaty to spaced foliations are upright. However, narrow transitions to recumbent structures occur where the regional strain increases as the suprastructure of the orogen passes gradationally into its infrastructure or abruptly into its basement. Inhomogeneous shortening of the Acadian suprastructure was accommodated by fold-related thrusts, which formed during the development of low-grade regional foliation. Although platy-foliated, syntectonically-veined or mylonitic rocks are locally gold-bearing, the amount of stratigraphical separation across ductile faults of Acadian or Hercynian age is commonly inconsequential. Therefore, despite the fact that these faults affect suprastructure, infrastructure and basement, they are probably not deep structures, although they may be sited along ancestral faults zones which root in the lower crust or mantle.

Types of Gold Mineralization

Gold deposits in the Appalachian Meguma, Avalon, and Gander terranes occur preferentially in the suprastructure of the fold belt and are tectonically localized in slate belts composed of variable amounts of sedimentary and volcanic rocks. Less commonly, gneiss and schist belts near the infrastructure-suprastructure transition

or near basement-cover contacts contain gold mineralization. The slate belts host two end-member types of mineralization: (i) nugget gold in Bendigo-type, saddle-reef, quartz-carbonate lodes (e.g., those in sandy and shaly flysch of the exotic Meguma Terrane of mainland Nova Scotia), and (ii) disseminated gold in Carolina-type, high-alumina, high-silica, sericitic schist zones (e.g., those in pyroclastic and epiclastic deposits of the Gander (?) Terrane of southwest Newfoundland). The stratigraphy, terrane-type, age and composition of the mineralized country rocks are largely incidental.

Origin and Nature of Fluids

In many, although not in all gold districts, mineralization and alteration occurs in association with igneous activity. Mineralizing fluids presumably originated from, or were heated by, granodiorite - tonalite plutons and satellite porphyries. In places, these granitoids are spatially associated with H_2O-, CO_2- and P-rich gabbro-diorite complexes and mafic dyke swarms, the loci of which are regularly spaced along some fault lineaments. All of these intrusive rocks probably formed in or passed through the deep basement and/or infrastructure of the orogen and ascended in sequence at various stages of regional deformation. Those of Acadian age were emplaced into the slate belts during high-T, low-P, dynamothermal metamorphism. Pseudo-porphyroblasts of sulphides, carbonates, aluminosilicates and phosphates (some containing rotated inclusion trails), record the unique physico-chemical conditions locally prevalent during periods of fluid-controlled, synmetamorphic, synplutonic alteration. Regional metamorphism at the time of emplacement of the gold-generating, felsic-mafic, composite intrusions and gold-bearing, quartz-carbonate, crack-seal, vein arrays was generally in the greenschist facies, although some host rocks were metamorphosed in the amphibolite facies before or after the introduction of magma and fluids.

Deformation Kinematics and Dynamics near Gold Deposits

Viscoelastic deformation near gold deposits was accomplished by two complementary processes: (i) dilation and synchronous shortening of intrusive bodies and veins in localized parts of fault zones or fold hinge zones, and (ii) a more widespread extension and flattening of the country rocks through the progressive development of coaxial folds and fabrics. Zones of large total strain are host to a greater variety and a larger number of syndynamic, synkinematic intrusions than zones that were never appreciably strained. Regardless of whether these zones are vertical or horizontal, quartz-carbonate veins and mafic-felsic sills and dykes are emplaced along and, to a lesser extent, across the foliation displaying the maximum anisotropy. Variably altered, mineralized, foliated and aged sheet-like plutons and sills occupy foliation-parallel, shear fractures in the ductile fault zones at the expense of their conjugate, cross-strike pair. While these rocks invariably suffer some of the strong regional deformation affecting the slate belts, gold veins and hypabyssal intrusions in the negligibly strained, simply folded areas between faults illustrate two, distinct, deformation styles. An autokinematic style of deformation affects dykes displaying syn-intrusion offset of host rock markers. Deformation of crystallizing magma between the walls of conjugate pairs of dilating dykes produced sigmoidal internal foliations that, in the case of one set, are perpendicular to the regional cleavage. In contrast, gold veins containing cleavage inclusions and laminated, fibrous or vuggy crystals are deformed by several orders and orientations of folds, and occupy systematic fractures parallel to the AB-, AC- and BC-kinematic planes of regional periclines.

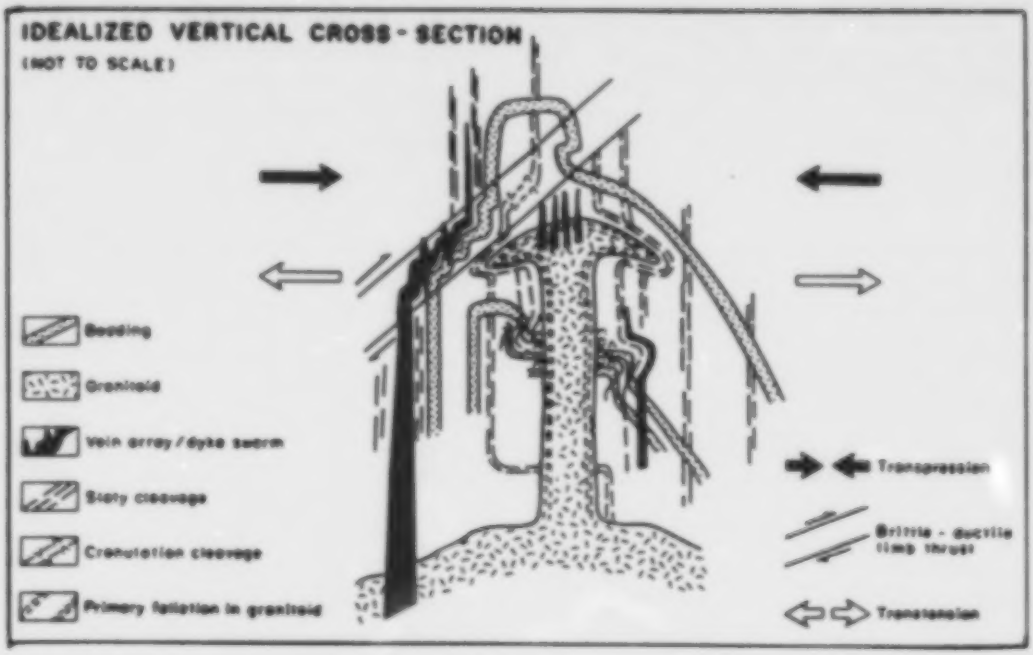

Figure 1: An illustration of some geometrical relationships between fold- and thrust related foliations, and auriferous veins and intrusions. Note the direction of transpressional and transtensional forces.

Roles of Transtension and Transpression in Localizing Gold Deposits

Regional systems of interrelated folds, transcurrent faults and thrust faults (reactivated by normal fault movements) occur along the southeastern margin of the Canadian Appalachians. Within most of the known goldfields on this margin of the orogen, particular structures are identifiable which act as conduits and provide traps for gold-bearing fluids, in much the same way that similar tectonic features localize oilfields in southern California. Contemporaneous and cyclic, brittle-ductile episodes of horizontal extension (transtension) and horizontal shortening (transpression) were operative throughout these systems, but their effect on intrusions of all scales has special ramifications for the localization of gold deposits. Orthogonal and oblique extension across developing foliations controlled the geometrical shapes, the growth textures and some of the deformation features of the gold quartz veins and variably altered hypabyssal intrusions. For example, in upright folds or faults invaded by vertical syntectonic intrusions, country rock layering as well as foliation-parallel veins and dykes were bent into flat orientations by extension and then rebuckled into steep attitudes by compression as progressive regional deformation focused on particular structures (see Figure 1). Since these processes were continuous, some individuals in the vein arrays and dyke swarms were generated while others were being folded or boudinaged. In places, granitoid plutons rose along steeply dipping faults or upright fold axial surfaces and spread laterally where these structures became flat-lying or recumbent, or where the roofs of plutons behaved diapirically. Here, ductile horizontal stretching locally produced

flat fabrics in the granitoids and distorted the once upright cleavage fans. It also caused the roofs of the granitoids and the adjacent parts of the fold hinge zones or thrust sheets to fail in extension, as space was created for vertical satellite intrusions emanating from the plutons. Pulses of mineralization, alteration and igneous activity occurred during periods of extension intimately associated with fold and foliation development and fault movement.

THE MEELPAEG SUBZONE OF CENTRAL NEWFOUNDLAND: SNOWSHOE POND (12A/7) AND GREAT BURNT LAKE (12A/8) AREAS

by

S. Colman-Sadd
Regional Mapping - Newfoundland

The Meelpaeg Subzone in central Newfoundland is included in the Gander Zone by Williams et al. (1988) (Figure 1). It is bounded on the east and west by Ordovician marine sedimentary, volcanic and ophiolitic rocks typical of the Exploits Subzone of the Dunnage Zone. The Snowshoe Pond and Great Burnt Lake areas, which were mapped at the 1:50,000 scale between 1984 and 1987, provide a transect across the Meelpaeg Subzone that includes its east and west tectonic boundaries and adjacent Exploits Subzone rocks (Colman-Sadd, 1987; Colman-Sadd and Swinden, 1984).

Stratified rocks of the Meelpaeg Subzone consist of a monotonous sequence of Ordovician(?) quartzitic sandstone and shale. These were intruded pre-tectonically by mafic dykes and pink biotite granite. Metamorphism was as low as biotite grade on the flanks of the subzone, but throughout the interior reached

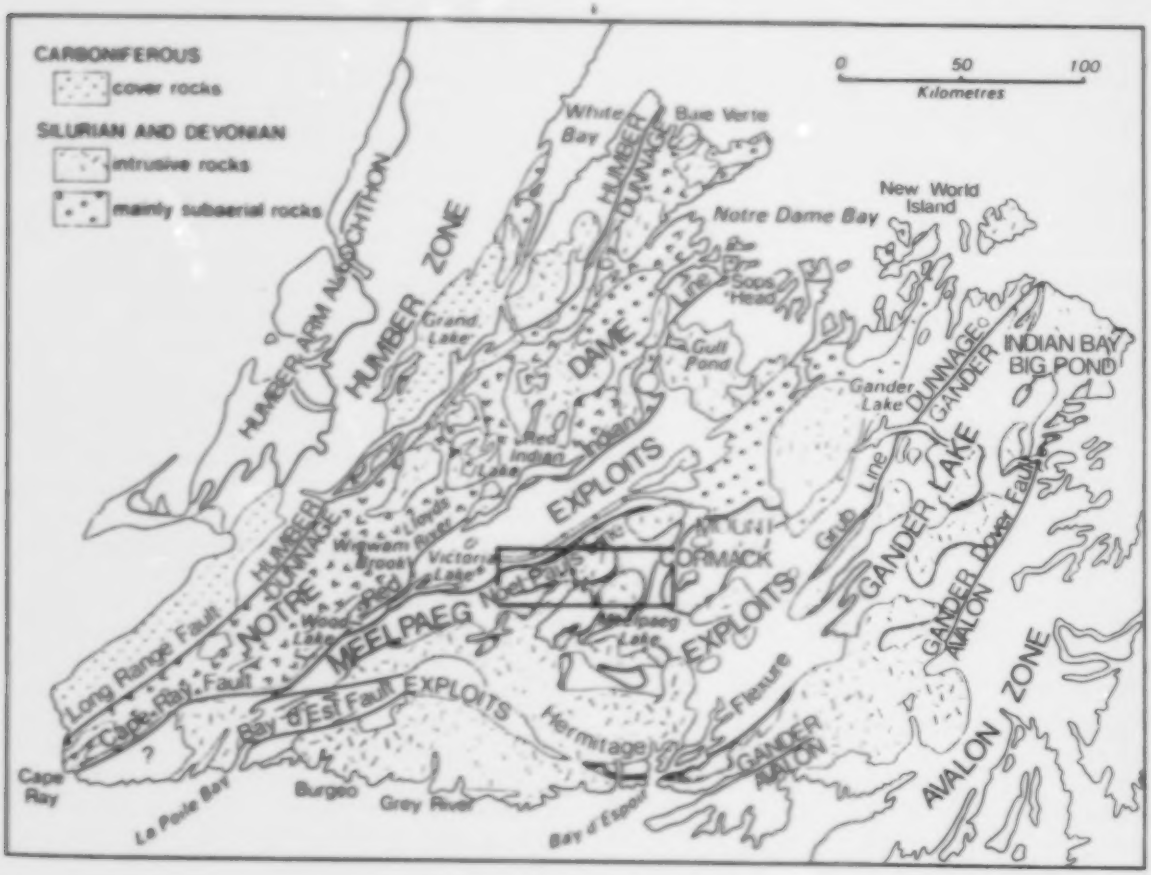

Figure 1: Zone map of Williams et al. (1988) showing the location of the Showshoe Pond and Great Burnt Lake map areas.

sillimanite grade, and in places created migmatitic gneisses. Deformation was relatively moderate in the interior, but extreme near the boundary faults on the flanks.

The Exploits Subzone, Cambro-Ordovician marine sedimentary and volcanic rocks, form the Central and Great Burnt Lake volcanic belts on the west and east of the Meelpaeg Subzone, respectively. These rocks are at biotite or lower metamorphic grade and are relatively, mildly deformed.

The boundary faults of the Meelpaeg Subzone are Noel Paul's Line in the west, and the Great Burnt Lake fault in the east. Both are foci of intense ductile shear. During the earliest recognized deformation in the Meelpaeg Subzone, Noel Paul's Line was on a west-directed thrust fault, bringing Exploits over Meelpaeg rocks. This thrusting affected the pre-tectonic, pink, biotite granite, indicating that it was preceded by earlier orogenic events. The fault was inverted by subsequent folding so that it now dips southeast.

The Great Burnt Lake fault records north-south transcurrent movement that was synchronous with the later deformation of the Meelpaeg Subzone and the folding of Noel Paul's Line. This movement was so intense, that it has obscured any earlier history of faulting.

Late syntectonic, biotite granodiorite and garnet-muscovite granite have been intruded mainly into the Meelpaeg Subzone. In some places, however, these plutons cut across the subzone boundaries into the Exploits Subzone. They therefore postdate the major movement on the boundary faults.

The potential for massive sulphide deposits and granite-related tungsten mineralization has been recognized for many years in the Exploits and Meelpaeg subzones, respectively. However, the possibility of mineralization, particularly gold, in the boundary faults has been largely ignored. This is especially surprising, since Noel Paul's Line, and to a lesser extent the Great Burnt Lake fault, are analogous to the Gander River Ultrabasic Belt, which is currently an area of intense gold exploration activity.

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SEQUENCE AND CYCLIC STRATIGRAPHY OF THE CAMBRIAN SYSTEM OF WESTERN NEWFOUNDLAND: A PRELIMINARY REPORT

by

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Work commenced this year on a three-year project to develop a detailed sequence and cyclic stratigraphic framework, for the Cambrian System in western Newfoundland. Building on previous lithostratigraphic and biostratigraphic studies, this project seeks to increase the resolution of correlations in the Cambrian System through a two-pronged approach: i) delineation of unconformity-bounded stratal packages whose internal depositional architecture can be modeled as the response of sediment accumulation to eustatic fluctuations (i.e., sequence stratigraphy), and ii) analysis of possible depositional rhythms in the stratigraphy (cyclic stratigraphy) which can be used for metre-scale correlation. Together, these approaches will provide a high-resolution correlation technique, which will enable geologists to not only correlate between geographically disparate Cambrian rocks, but also to predict the stratigraphic position of facies favourable for mineralization in both the subsurface and frontier exploration areas.

During this past field season, work focused on the Middle and Upper Cambrian rocks exposed in coastal outcrops along the Port au Port Peninsula, Southeast Arm Bonne Bay and Goose Arm Bay of Islands. Detailed stratigraphic sections were measured and samples were taken for petrographic examination. Field observations were directed at determining depositional environments of sediments and the nature of the changes between these environments, which resulted in stratigraphic superposition. Subtle discontinuities and stratigraphic breaks were discovered, which will be critical to interpretation and recognition of stratal packaging. Great care was taken to stratigraphically bundle carbonate facies during the field survey. It is intriguing that the carbonates of the Port au Port Group, do not readily exhibit discernable cyclicity, which is otherwise extremely characteristic of platform carbonates throughout both the Proterozoic and Phanerozoic records.

The stratigraphic data collected, will be synthesized for the areas examined and manipulated via statistical computer applications, including graphical time-space and time-series analyses. Regional carbonate depositional geometries, and vertical stratigraphic packaging in the Cambrian System will be discovered only through analyses of this type.

Additional field surveys during upcoming field seasons, in the Lower Cambrian Labrador Group will permit the sequence stratigraphic and cyclic time-series analyses, to be expanded into this mixed carbonate and siliciclastic succession. Thus, a comprehensive and integrative stratigraphic framework of the early Paleozoic autochthonous platform rocks will be in place, for determining regional correlation and exploration. If, in

fact the carbonate and siliciclastic facies of the Labrador and Port au Port groups are stacked in stratigraphically predictable patterns within unconformity-bounded sequences, then this framework will be a powerful tool in exploring for unconformity-related carbonate dissolution. Such dissolution events are typical of MVT mineralization, such as the zinc deposits at Daniel's Harbour and Round Pond.

EVOLUTIONARY TRENDS IN GRANITE PLUTONISM IN SOUTHERN NEWFOUNDLAND

by

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Studies of the granites of southern Newfoundland, carried out under the 1984-1989 Canada - Newfoundland Mineral Development Agreement, have led to the recognition of four major ages of plutonism, each with a characteristic lithology and structural setting (Figure 1).

The Roti Granite represents the oldest component and contains a pluton, dated at 563 Ma. The Burgeo Intrusive Suite which is the largest batholith, has representatives of three younger components, and contains early-, late- and post-kinematic granite plutons. The oldest component is a 429 Ma synkinematic granitoid pluton; and the lithologically similar Gaultois Granite is 421 Ma. A late synkinematic granite in the Burgeo Intrusive Suite has been dated at 415 Ma. Similar granites, such as the eastern part of the North

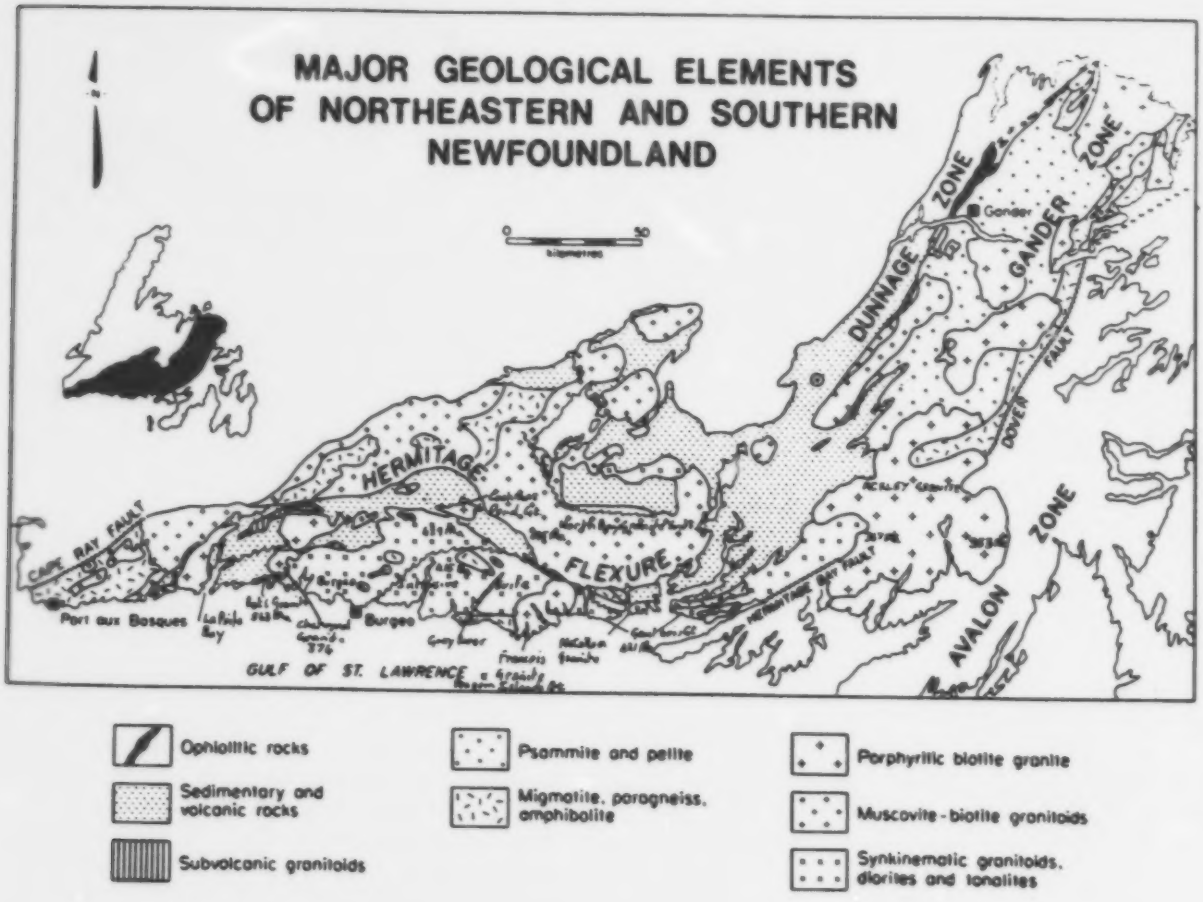

Figure 1: Major tectonic elements of northeastern and southern Newfoundland showing the distribution of the major granitic batholiths.

Bay Granite Suite and the Cochrane Pond granite are interpreted to be of similar age. The Burgeo and, to a larger degree, the North Bay suites contain post-kinematic components that have also been intruded by the post-kinematic Francois and Chetwynd granites. The latter granites have intruded across major shear zones and regionally metamorphosed, sedimentary and volcanic rocks. A date from an undeformed pluton of the North Bay Granite Suite, indicates that regional tectonism had ceased by 396 Ma. An Ar/Ar cooling age of 372 Ma has been reported from the Chetwynd Granite (Chorlton and Dallmeyer, 1986). Similar plutons, such as the Ackley and Harbour Breton granites, have given Ar/Ar and Rb/Sr ages which range from 377 to 353 Ma. The Harbour Breton Granite has intruded undeformed, fossiliferous Upper Devonian strata.

The Roti Granite is a small elongate body that consists of at least two distinct plutons, the older of which (563 Ma) is dominantly tonalite. The Roti Granite is intruded by diabase dykes, which have been deformed with the plutonic rocks. This association, coupled with the age of the Roti Granite suggests a possible link with late Precambrian events in the Avalon Zone.

The Silurian, early synkinematic granitoids of the Burgeo Intrusive Suite and the Gaultois Granite are biotite-rich, hornblende-bearing, coarse grained, feldspar-porphyritic granodiorites containing regional D_1 (Silurian) foliations. Gabbro is also associated with these phases. The Silurian, late-kinematic components of the Burgeo Intrusive Suite, North Bay Granite Suite, and the McCallum and Cochrane Pond granites are mainly biotite - muscovite granites and contain only regional D_2 (Silurian) foliations. Xenoliths of early synkinematic granite occur within the late synkinematic granites. The post-kinematic granites are dominantly coarse-grained, K-feldspar-porphyritic to equigranular, biotite granites. These comprise major portions of the western North Bay Granite Suite, virtually all of the Francois and Chetwynd granites, but only a small portion (approximately 10 %) of the Burgeo Intrusive Suite. Deformation of these plutons is restricted to late brittle faults.

Geochemical variation reflects the sequence of intrusion indicated by radiometric ages and structural relationships within the the major intrusions. SiO_2 frequency distributions (Figure 2) indicate a trend towards more siliceous compositions with time. The older batholiths, such as the Burgeo Intrusive Suite, contain a high proportion of basic to intermediate compositions. The younger batholiths such as the North Bay Granite Suite lack intermediate compositions and are dominated by moderately to highly acidic compositions whereas the youngest batholiths such as the Chetwynd and Francois granites are dominated by highly acidic granites.

The evolution of mid-Paleozoic granite plutonism is centred on a major orogenic event which has been commonly interpreted to be the Lower Devonian Acadian Orogeny. Dating of the granites shows that the main deformation predates the Acadian orogeny and may be equivalent to the Silurian Salinic 'Disturbance' of Maine, and the Caledonian and Scandian orogenies of northwest Europe (see Dunning et al., this volume).

The margins of the granites are commonly the site of extensive, massive quartz veins and areas of quartz-veined granite and metasediment. Local occurrences of magnesite and serpentinized ultramafic rocks along the northern contact of the North Bay Granite Suite indicate that

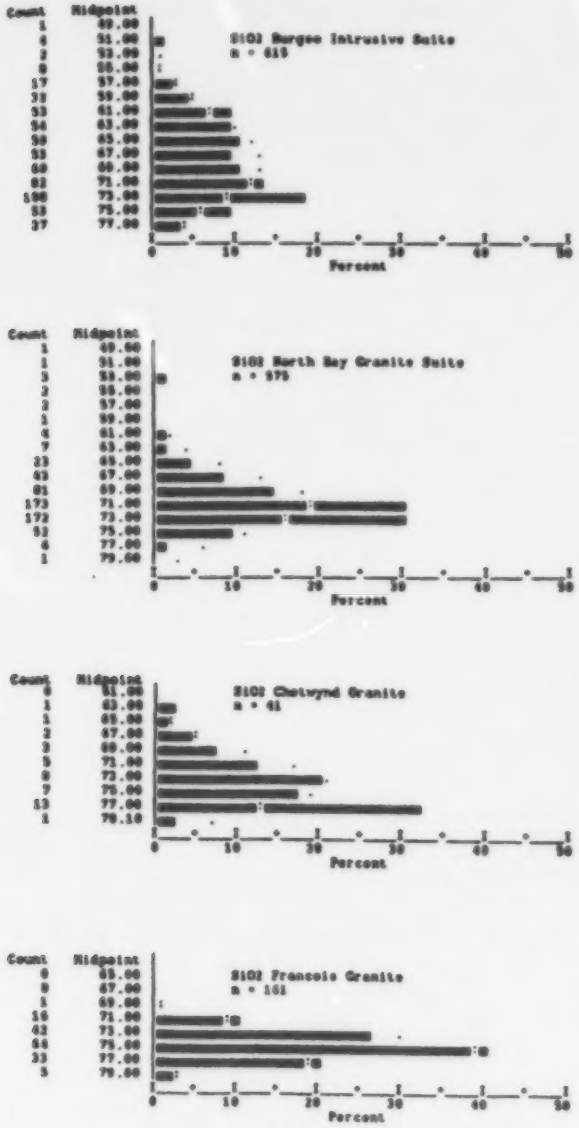

Figure 2: SiO_2 frequency diagrams for the Burgeo Intrusive Suite, North Bay Granite Suite, Chetwynd and Francois granites. Dotted curve indicates the normal curve for each unit.

the marginal shear zones are fundamental breaks with regional significance. It is perhaps of economic significance that Murray and Howley (1881, page 227) described green, magnesia - chromium aluminosilcates (pyrosklerite = fuchsite?) in abundant, angular, green and white, brown-weathering, magnesian rock, in the vicinity of one zone, from the shores of Long Pond, west of St. Alban's. This rock may be a carbonated ultramafic and equivalent to 'virginite'.

Granophile element mineralization and anomalously high radioactivity are associated mainly with the post-tectonic granites. The Francois Granite is one of the most radioactive granites in Newfoundland; this is clearly demonstrated in the radio-element maps of Broome et al. (1987). This is a result of extreme differentiation of the granite and subsequent enrichment in incompatible elements such as U and Th. The granite is composed of well-developed ring complexes and the highest values come from the youngest components.

Significant tungsten, molybdenum or tin mineralization are now well known from the North Bay granite at Granite Lake, southern Ackley Granite, and Burgeo Granite at Grey River. Less well known is the gold mineralization, discovered north of the community of Grey River, by the Buchans Mining Company (Bachyrycz 1956), and subsequently confirmed by Asarco (Thurlow 1981), in altered wall-rock adjacent to a polymetallic quartz vein within the Burgeo Granite. Gold mineralization at Hope Brook, which is found in Precambrian strata, is in part spatially and perhaps genetically related to the intrusion of the Roti Granite. High-grade uranium mineralization in felsic tuffs of the Bay du Nord Group is at least spatially related to granite.

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MAPPING AND STRATIGRAPHIC STUDIES AND ECONOMIC POTENTIAL OF CAMBRO - ORDOVICIAN CARBONATE ROCKS OF THE GREAT NORTHERN PENINSULA, WESTERN NEWFOUNDLAND

by

Ian Knight and W.D. Boyce
Regional Mapping - Newfoundland

Mapping of the autochthonous, Cambro-Ordovician, dominantly carbonate rocks of the Humber Zone on the Great Northern Peninsula has been essentially completed. This work begun in 1976, involved 1:50,000 scale mapping, detailed stratigraphic studies and micro- and macrobiostratigraphic studies. It has led to the establishment of a firm stratigraphy for the 1600 m succession, a basic understanding of geological events and sedimentary settings of large- and small-scale sequences that comprise the Newfoundland platform, and the stratigraphic framework of base metal and industrial commodities in the area.

Paleontological and biostratigraphical studies describe a preliminary trilobite zonation for western Newfoundland. This latest Early Cambrian to early Middle Ordovician zonation, may eventually prove to be (at least partly) applicable to other areas of the Appalachian-Caledonide Orogen. The studies to date have enabled numerous correlations to be made at the specific level.

Shelf accretion at the Lower Paleozoic continental margin was the result of the interaction of subsidence, the interplay of various scales of sea-level rise and fall, sedimentation rates and tectonic activity. The margin evolved in two distinct stages. A long-lived (approximately 80 million years), passive margin stage lasted from the middle Early Cambrian to earliest Middle Ordovician and includes sedimentary rocks of the Labrador, Port au Port and St. George groups. The short-lived second stage (approximately 10 million years), includes only carbonates and shales of the early Middle Ordovician Table Head Group and accumulated at a tectonically unstable, convergent margin. Sediments of the passive margin are for the most part shallow water, reflecting several, mostly eustatic, events of shelf drowning and subsequent sedimentary progradation that produced mega-cycles (100's of metres) of subtidal followed by peritidal "half-cycles". The convergent margin sediments consist of an upward-deepening sequence that resulted from the downwarping and collapse of the margin as Taconic subduction and orogenesis destroyed the margin. A regional unconformity with widely developed surface and subsurface karst, the St. George Unconformity, separates the two stages. Evidence of faulting and brittle fracturing of Lower Ordovician carbonates during this episode of subaerial exposure is abundant.

Generally, each transgressive-regressive cycle in western Newfoundland is characterized by its own distinct trilobite faunal succession; further, within each succession, discrete trilobite biofacies are recognized. This is particularly true in the Middle Cambrian and Early Ordovician sequence. For example, it has been found that lime wackestones and boundstone mounds generally contain different (but consistent) trilobite species associations, from each other. Because nearshore, shallow water shelf faunas and off-

shore, deeper water shelf faunas can be distinguished by biofacies analysis, it is a useful tool for outlining major facies belts, and paleogeographic reconstructions, which may prove to have economic significance.

The platformal sequence begins with a basal mixed siliciclastic and carbonate sequence, the Labrador Group, which is an onlap - offlap sequence that was laid down following Early Cambrian marine flooding of the continental margin. A succession of K_2O-rich shales and relatively pure quartz arenites deposited respectively during the onlap/offlap phases of this mega-sequence are high tonnage commodities in the northwest of the area.

The succeeding Port au Port Group is a Middle to Late Cambrian succession of dominantly low-energy, peritidal fine-grained dolostones and shales that accumulated in the inner part of a narrow shelf behind a rim of carbonate sand shoals. The dolostones postdate following Middle Cambrian transgression and subtidal limestone deposition. Dolomitization of the upper part of the Middle Cambrian limestone provided a suitable host for minor sphalerite and galena mineralization which is also hosted locally by fracture porosity and structurely-controlled breccias in the lower part of the overlying dolostones.

Lower Ordovician carbonates are the host to the main base metal deposits of the area but also contain huge reserves of industrial stone. The St. George Group consists of two mega-cycles, comprising lower subtidal carbonates followed by overlying "half-cycles" of peritidal carbonates, that culminated in each mega-cycle in a regional disconformity. The succession beneath the disconformities was modified by subsurface diagenesis in two important ways. Firstly, strata-bound dolomitization replaced all or large parts of the subtidal carbonate "half-cycle" probably by subsurface mixing of meteoric and saline waters during the deposition of the upper "half-cycle" and during subaerial exposure. Secondly, widespreaddissolution produced extensive networks of rock-matrix breccia bodies, that probably represent subsurface karst collapse breccias. Emplaced into the dolomites and mostly adjacent to these breccias are a number of sphalerite ore bodies,that include the producing mine at Daniel's Harbour in the upper mega-cycle, and the Round Pond prospect in the lower mega-cycle. The dolomites of the upper mega-cycle are up to 60 m thick and provide huge tonnages of low-silica, metallurgical-grade rock for agricultural and industrial purposes.

Where the subtidal limestones of the lower "half-cycle" are not affected by the dolomitization, large tonnages of good quality, pure, metallurgical limestones are preserved in both megacycles. Characteristically light grey to white, these limestones are typically peloidal carbonate sands, microbial mounds and fenestral. They occur in thick, massive beds that suggest that the microbial mounds with spectacular depositional fabrics and fossils would make high-quality decorative stone. Locally, the same limestones and some pure limestones from the top of the underlying Cambrian carbonate sequence are metamorphosed to high grade marble deposits in parautochthonous thrust slices near Canada Bay. Assessment of the economic potential of these marbles and pure limestones as mineral fillers is presently underway by several companies.

The Table Head Group is a succession of peritidal carbonates, overlain by subtidal limestones and shales, that reflect the collapse and drowning of the margin during the early stages of Taconic orogenesis.

The basal peritidal limestones include a succession up to 50 m thick of thick-bedded, light grey limestones; thse limestones include fossiliferous and fenestral carbonate sands and mudrocks, that are both pure and massive suggesting that they have potential, both as metallurgical limestone and as a decorative stone.

Compilation of the collected data will be documented in a series of geological reports to be published over the next two years. At the same time analysis of detailed stratigraphic sections will be undertaken for specific parts of the carbonate sequence with the intention of correlating small scale sequences and sequence bundles bounded by disconformities (see Cowan, this volume). It is hoped that this will lead to a better understanding of the controls and events that influenced the developments of the platform during the Lower Paleozoic and perhaps to the delineation of further mineralization in the Great Northern Peninsula area.

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MAP COMPILATION PROGRAM - INSULAR NEWFOUNDLAND

by

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1:250,000 Coloured Map Series

The objective of this program is to produce 1:250,000 coloured geological maps of insular Newfoundland. At this scale, eleven maps are required for a complete coverage of the island. The proposed boundaries of the mapsheets, relative to the National Topographic System (NTS) grid, are given in Figure 1.

The intent is to produce the 1:250,000 maps, as the 1:50,000 mapping becomes complete for each area. The original geology map and legend will be produced in conjunction with the project geologist(s) most familiar with each area. The role of the authors (of this report) is to standardize the presentation of the map series, as well as to edit individual maps.

The Avalon Peninsula map (King, 1988) is the first map of this series to be produced. The map has been designed to incorporate as much geological information as possible. The base map was constructed from NTS 1N, 1K, 1L and 2C, with cultural information selectively deleted to provide space for the geological data. All topographic data were retained to enable the use of the map as a navigational aid. Emphasis is placed upon legibility of topographic information throughout the map series.

The Avalon map is a representative of future maps in the series. It contains the following features which will appear on each map:

1. Index maps - Geographical and geological index maps are included to show the coverage of the map area with respect to the NTS system and within the regional geological framework of Newfoundland.

2. Reliability diagram - This figure will show the coverage and scale of source maps used in the compilation.

3. Reference list - Works cited are those appearing on the reliability diagram, the original references for geochronological data supplied in the legend, descriptions of important fossil or mineral occurrences, and regional overviews.

4. Geological cross-section - A true-scale cross-section, with no vertical or horizontal exaggeration, will accompany each map.

5. Diagram of major stratigraphic relationships - The purpose of this figure is to show the main stratigraphic and intrusive relationships within the map area, and the main structures where deformation has affected the developing stratigraphy. It is thus a synthesis of several cross-sections and is not drawn to scale.

6. Simplified map - A simplified geological map is included at approximately 1:1,000,000 scale. It aims to show the spatial relationships of the main geological elements of the area, largely to assist unfamiliar readers and to allow identification of major structural and stratigraphic features.

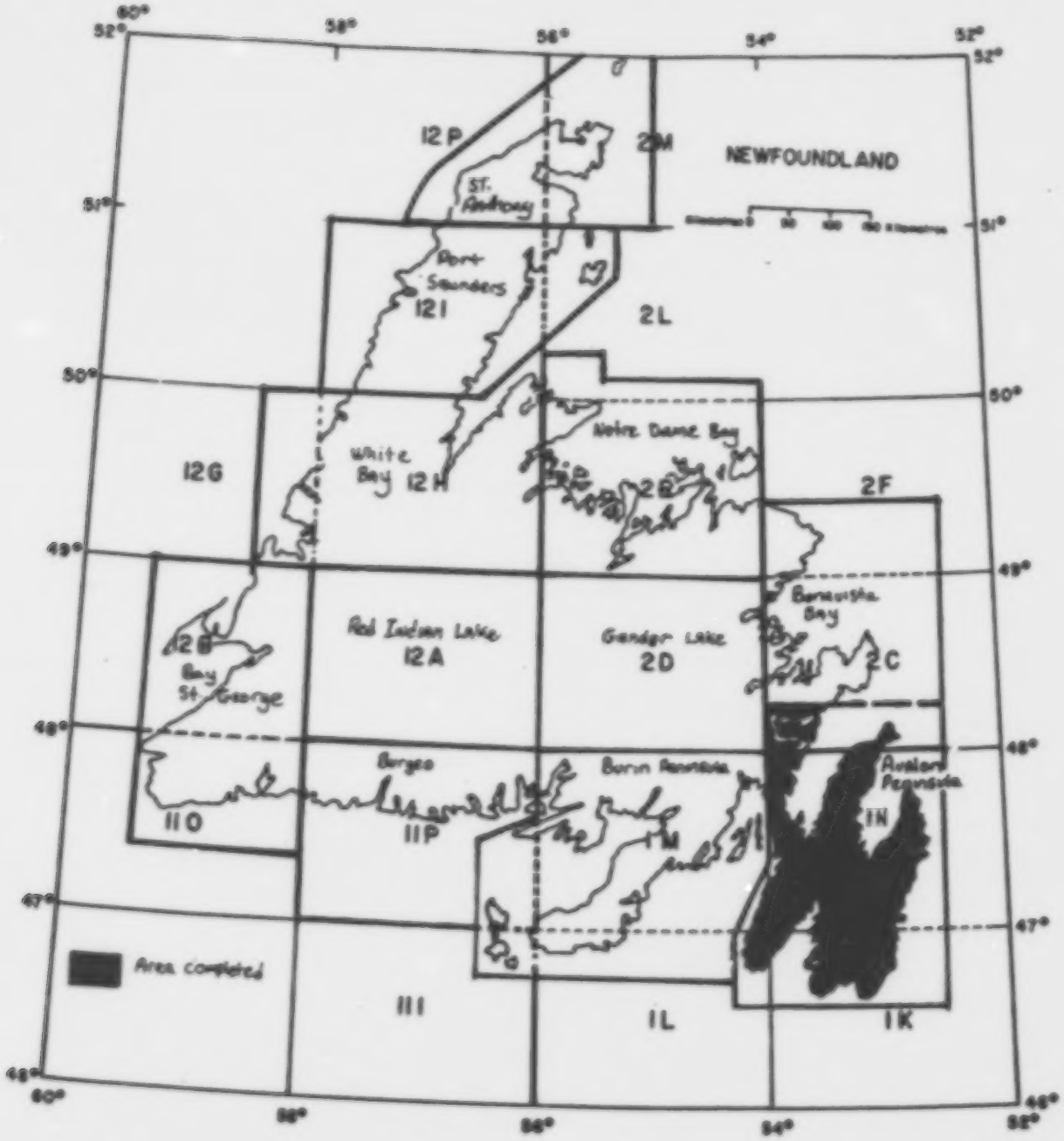

Figure 1: 1:250,000 NTS grid showing proposed boundaries (heavy solid lines) and names of map sheets in the coloured map series.

7. Diagrammatic legend - The legend style is diagrammatic and is based on the legends used by the Bureau of Mineral Resources, Geology and Geophysics of Australia. This particular style was chosen because it conveys far more stratigraphic information than the standard "box and script" style. The arrangement of units reflects their temporal relationships and approximate geographical distribution.

8. Other - On maps which include coastlines, bathymetric contours and offshore geology will be included, where the data is available. The trace of distinctive geophysical features will be included where these are seen as significant on a regional scale.

The foregoing is a summary of the major features of the Avalon map and the map series in general. A more detailed discussion which will be published later, will include a discussion of the rationale for selection of the colour scheme, use of symbols and the construction of the diagrammatic legends. It is planned that the Burin Peninsula mapsheet will be the next in the series.

1:1,000,000 Compilation Map

A 1:1,000,000 coloured geological map of insular Newfoundland is also being produced from original sources, as part of the compilation program. This map has been in the working stage for about one year and at present is in the editorial process. The objective of this map is to provide general geological information of the island at a glance, and in particular to serve as an easily understood visual aid during oral presentation. As such, detail is left to maps of more suitable scale. The emphasis is to allow quick recognition of the main geological elements of the Island. The criteria for grouping of individual units is age and rock type. A colour scheme, emphasizing rock type, has been selected that should be familiar to most geologists. In keeping with the 1:250,000 scale map series, a diagrammatic legend is used. Both map and legend will comprise a single sheet. Geological information on the near-offshore may be included, depending upon available coverage. The map should appear in print in 1989.

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PALEONTOLOGICAL INVESTIGATIONS IN NEWFOUNDLAND, 1988

by

W.D. Boyce and J.S. Ash
Regional Geology - Newfoundland

WESTERN NEWFOUNDLAND

Cow Head to Corner Brook

Boyce and Dr. S.H. Williams (Memorial University) are jointly studying an unusual Late Tremadoc Acado-Baltic type graptolite-trilobite fauna from the Cow Head Group of the Humber Arm Allochthon. Additional trilobite material was obtained during the western Newfoundland pre-meeting field trip of the Fifth International Symposium on the Ordovician System.

Boyce is also working with Dr. J.W. Botsford on late Middle Cambrian to Early Ordovician trilobite faunas from the Cooks Brook Formation (Curling Group) of the Humber Arm Allochthon (Botsford et al., 1986).

Port au Port Peninsula

Trilobites are generally lacking in the Watts Bight and Aguathuna formations (St. George Group) of western Newfoundland, because these units consist mainly of unfossiliferous dolostone. However, on the eastern end of Port au Port Peninsula, the formations include limestone beds. Here, trilobites (as well as brachiopods, cephalopods and gastropods) were collected from two significant localities.

The Watts Bight Formation at Green Head (south of The Gravels) yielded the Gasconadian (Early Canadian) trilobite Hystricurus ellipticus (Cleland, 1900). Abundant articulate brachiopods were also collected. The fossils were recovered from the Green Head Mound Complex of Knight and James (1987, Figure 4).

The Aguathuna Formation north of The Gravels includes several limestone beds. Several trilobite specimens were discovered from one of these, by field trip participants Ji Zailiang, Chris Barnes and Felicity O'Brien. Boyce subsequently collected additional material from this new locality. At least three trilobite species are present. The presently unidentified material is to be jointly studied with Dr. R.A. Fortey (British Museum - Natural History).

CENTRAL NEWFOUNDLAND

Gander Lake

The Davidsville Group fossil locality of Jenness (1963) and McKerrow and Cocks (1977) was re-examined. The locality is approximately 2 km west of Little Harbour on the north shore of Gander Lake. An extensive collection of Late Arenig-Early Llanvirn brachiopods and trilobites was made from an exposure of highly deformed micaceous slate. The following were recovered:

Trilobita

Annamitella sp. cf. A. insulana Dean, 1973

Brachiopoda-Articulata

orthid aff. Eostrophomena of McKerrow and Cocks (1977)

Hesperorthis sp. of McKerrow and Cocks (1977)

The presence of Annamitella supports the idea that the Reach Fault is not the Iapetus Ocean suture (Stouge, 1980a,b,c; Boyce et al., 1988; Boyce, 1988b).

Cooperative paleontological investigations were continued with Drs. R.J. Elias (University of Manitoba), R.B. Neuman (Smithsonian Institution) and S. Stouge (University of Copenhagen).

EASTERN NEWFOUNDLAND

Kelligrews

During field preparations for Trip A8, - Cambrian trilobite faunas on the Avalon Peninsula, of the 1988 Annual Meeting of the Geological Association of Canada (Boyce, 1988a), Early Cambrian trilobites were discovered at the Kelligrews' quarries. The following were collected:

Callavia broeggeri (Walcott, 1888)

Strenuella strenua (Billings, 1874)

The trilobites were obtained from red and green shale and siltstone of the Brigus Formation.

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GEOLOGY OF THE LONG RANGE INLIER, NEWFOUNDLAND

by

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In northwestern Newfoundland, Proterozoic basement exposed in the Long Range Inlier comprises three lithostratigraphic groupings: (i) a high grade gneiss complex; (ii) Grenvillian granitic-charnockitic plutons; and (iii) latest Proterozoic mafic dykes. The gneiss complex comprises granulite and amphibolite derived from protoliths at least 1.55 Ga old. Metamorphic grade and paleotemperatures increase southwestward. Metamorphic pressure ranges from 5 to 8 kbar throughout the inlier. Northwest-trending, large-scale folds dominate the structure of the gneiss complex. The age of these fold structures relative to the Grenvillian plutons is not certain.

The voluminous granitic-charnockitic plutons were emplaced between 1020 and 970 Ma, and are coeval with similar granitoid rocks in the Grenvillian Province of southern Labrador. These plutons delineate a 350 km wide Grenvillian magmatic terrane, south of a 225 km wide fold and thrust belt which is bounded to the north by the Grenville Front. A 30 km wide shear zone separates these two terranes in southeastern Labrador. By analogy with Cenozoic orogens, the Grenvillian plutons are interpreted to result from the partial melting of Labradorian crust (ca. 1.65 Ga) during thrust-induced crustal thickening. In the Long Range Inlier, biotite-hornblende granites have geochemical signatures consistent with an anatectic origin, however, coeval charnockitic rocks appear to have been derived at least in part from mantle source components. Both types of granitoids were deformed late during this plutonic episode (970 Ma).

Uplift and rifting of the inlier during the latest Proterozoic resulted in the emplacement of tholeiitic dykes of the Long Range swarm.

Paleozoic orogenies are manifested by mafic dykes, a felsic pluton (Devils Room pluton), and by a structural and metamorphic overprint near the southeastern margin of the inlier. The Long Range dykes are convenient markers of Paleozoic orogenesis. An east-dipping thrust fault (Long Range frontal thrust) separates the inlier, from the Paleozoic platform in the foreland to the west. Geophysical evidence suggests minimal horizontal displacement across this fault.

Gold prospects in Grenvillian granite and nearby quartzofeldspathic gneiss and Paleozoic cover rocks near White Bay have the greatest economic potential.

GEOLOGY OF THE SOUTHERN LONG RANGE, NEWFOUNDLAND

by

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The southern Long Range consists of five terranes, separated by major faults. To the west, the region between the Long Range and Grand Lake faults (Figure 1) comprises westward transported thrust slices of granulitic gneisses (1500 Ma); and is intruded by an anorthosite massive about 1280 Ma, which is overlain by metasedimentary and amphibolitic rocks. These rocks are in turn overlain by quartzite, pelite and minor marble, correlated with the Fleur de Lys Supergroup, which are intruded by aklaki granite about 617 Ma. This region comprises a sub-zone of the Humber Zone in the terminology of Williams et al. (1988). The Long Range fault marks a profound structural break, along which thermal disturbance of isotope systems continued as late as 370 Ma. East of the Long Range fault the Central Gneiss Terrane comprises high-grade metasedimentary rocks, whose protolith of uncertain age was metamorphosed to granulite facies and intruded during the middle Ordovician (450 Ma), by a voluminous suite of mafic enclave-bearing tonalite, trondhjemite, granodiorite and granite. These plutons characteristically exhibit penetrative deformation, but a chemically distinctive suite of post-tectonic mafic plutons (435 Ma) shows that by Early Silurian time, penetrative deformation had ceased and the region was cratonized.

To the north, the Central Gneiss Terrane is truncated by the Little Grand Lake fault, along which the Notre Dame sub-zone of the Dunnage Zone, characterised by little-deformed, mid-Ordovician plutonic rocks and peralkaline Silurian granite, was thrust southward. Like all other major breaks in this region, the Little Grand Lake fault exhibits both early ductile deformation and late brittle deformation. To the east the Central Gneiss Terrane contacts an extension of the Exploits sub-zone of the Dunnage Zone, characterised by theAnnieopsquotch ophiolite complex, across the Lloyds River fault. The Exploits sub-zone ends just west of the Burgeo Highway, and the Central Gneiss Terrane contacts the Maelpaeg subzone of the Gander Zone along the Victoria River fault. This fault is marked by a very large dextral mylonite zone, which appears to mark the most profound structural break in this region. To the southeast metasedimentary rocks of uncertain age were migmatised in Silurian time (420 Ma), producing distinctive tourmaline-beryl granites.

The best prospecting areas appear to be major fault zones with late thermal disturbance. Both the Long Range and Victoria River - Cape Ray systems exhibit such phenomena, and both are known to be mineralized with gold.

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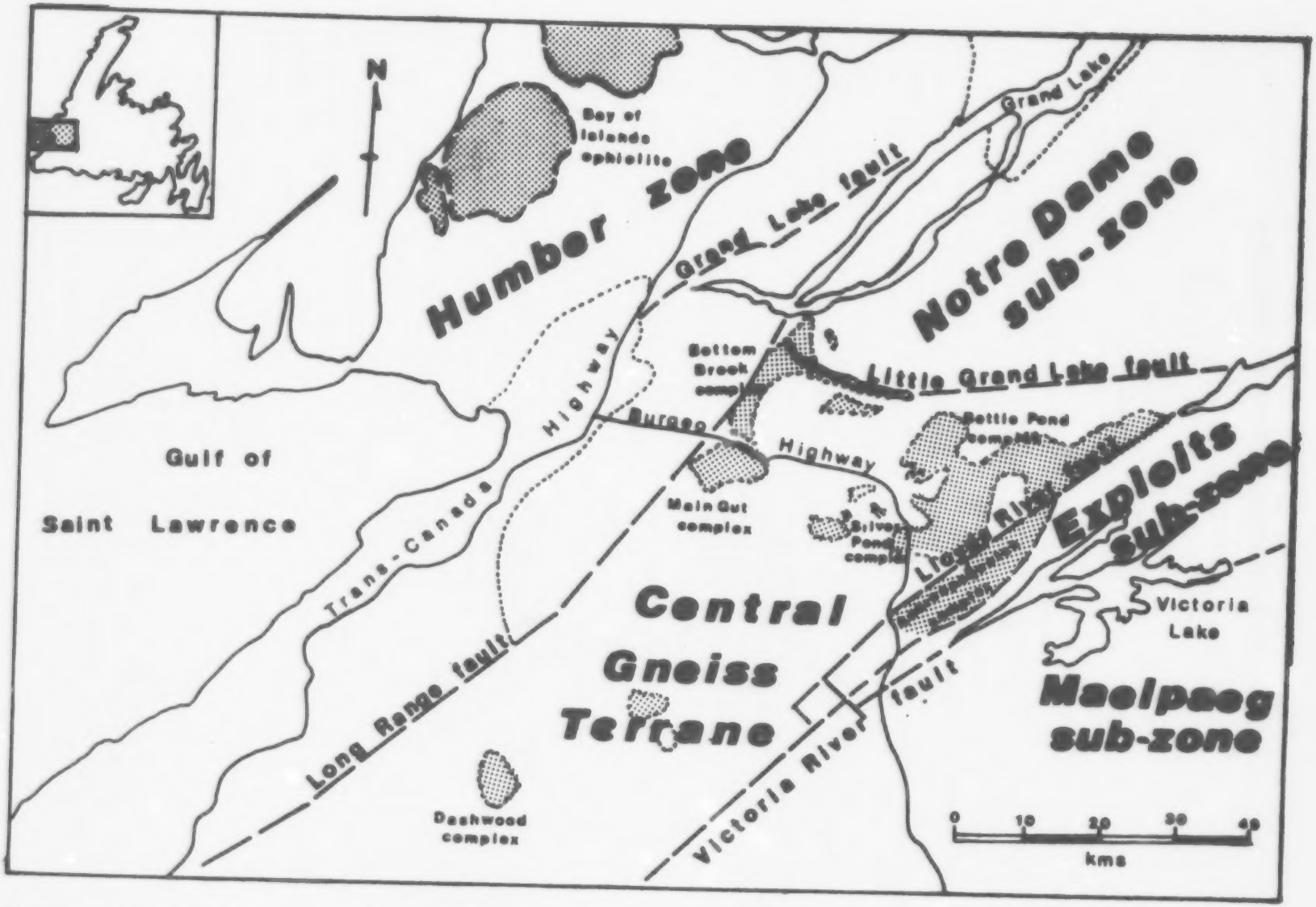

Figure 1. Geology of the Southern Long Range, Newfoundland

INVESTIGATIONS OF POTENTIAL PGE ENVIRONMENT IN NEWFOUNDLAND OPHIOLITES

by

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Field work for the Metallogeny of Newfoundland Ophiolites Project (funded by the Canada-Newfoundland Mineral Development Agreement) during the 1988 season consisted of mapping and sampling at selected localities to complete, at a reconnaissance level of detail, documentation of some potential platinum group element (PGE) and Au environments associated with ophiolitic rocks. This work complements investigations by other participants in the Metallogeny of Newfoundland Ophiolites Project (e.g., Dunsworth et al., 1986; Dahl and Watkinson, 1986; Edwards, in prep.). Collectively, these separate but integrated investigations have been aimed at providing a broad spectrum of information on geological and geochemical parameters, that control mineral deposit types of current exploration interest.

Among the localities investigated are two which represent geological environments that appear to have the potential for platinum group element enrichment. The one at Liverpool Brook, Bay of Islands ophiolite, appears to represent sulphide and PGE concentration during remelting of gabbro by its interaction with an ultramafic melt or a sulphur-water volatile phase during mantle deformation. The other, in the Betts Big Pond area of the Betts Cove ophiolite, appears to represent the mobilization and concentration of PGE and Au by the progressive serpentinization and carbonation of ultramafic rocks. The PGE concentrations at both localities do not represent conventional PGE mineral deposit types and the economic potential of the mineralization types still remains to be demonstrated.

Liverpool Brook

The Liverpool Brook sulphide occurrence is centred around 49° 15' 35", N 58° 2' 57" W on the eastern side of Liverpool Brook, North Arm Mountain in the Bay of Islands Ophiolite Complex. It was discovered by Mr. Clyde Childs of York Harbour, in 1973, who brought the occurrence to the senior author's attention in 1986. The occurrence consists of lenses of anorthosite, anorthositic gabbro and feldspathic pyroxenite, containing interstitial pyrrhotite with minor chalcopyrite, violarite and pentlandite in gabbro and olivine gabbro host rocks. The sulphidic lenses are up to 5 m thick and 20 m long, and may have sharp or gradational contacts with adjacent rocks. The lenses are generally elongated parallel to the regional foliation, which locally trends in a northeasterly direction. This is also the trend of major lithological contacts.

The sulphides occur over a north-south horizontal distance of at least 400 m. The east-west extent of the sulphide zone was not determined because the occurrence is largely within a landslide area, but appears to be at least 70 m wide. On a regional scale, the occurrence is located within layered gabbro near its contact with layered ultramafic cumulates. Locally, the gabbroic host rocks to the sulphide lenses have been invaded by wehrlite and troctolite. The sulphide-bearing zone is characterized by anomalous compositional and textural variants of feldspar-pyroxene rocks, ranging from granoblastic anorthosite to pegmatitic pyroxenite. Although in thin section textures are generally

typically magmatic with interstitial sulphide, evidence for feldspar resorption is not uncommon. These features seem to be most simply explained by the local, partial melting of gabbro and the heterogeneous redistribution of its constituent components. Selected analyses of a reconnaissance set of samples collected in 1986 illustrate the variation of ore components:

S(%)	Cu(%)	Ni(%)	Pt (ppb)	Pd (ppb)	Au (ppb)
14.5	0.20	0.40	80	50	9
14.4	0.12	0.33	<10	16	3
12.0	0.73	0.41	30	7	170
4.42	0.32	0.19	<10	< 2	43
0.13	0.02	0.03	50	14	4

A more extensive and representative set of analyses is currently being carried out. Metasomatic processes of the area are currently being investigated by Jean Bedard, Geological Survey of Canada.

Betts Big Pond area

The motivating factor behind investigating the Betts Big Pond area of the Betts Cove ophiolite is its analogy to the Unst ophillites, Shetland Islands, U.K. At Unst, analyses of grab samples have grades of up to 25 ppm Pt, 46 ppm Pd, 8 ppm Au (Gunn et al., 1985; Prichard, et al., 1986). Although the genesis of the PGE mineralization is still controversial because most of the analyses were carried out on chromitites, the association of the PGM with relatively low temperature Ni-Fe sulphide-arsenide assemblages and serpentine, chlorite and carbonate gangue minerals, together with the occurrence of up to 2.5 ppm Pt and 5 ppm Pd in partially serpentinized and weakly carbonated dunite, strongly suggests a hydrothermal concentration of PGE (Gunn et al., 1985).

In collaboration with Drs. A.G. Gunn and M.T. Styles of the British Geological Survey, it has been established that the style of progressive serpentinization and carbonation of ultramafic rocks that occurs on Unst is duplicated in the Betts Big Pond segment of the Betts Cove Ophiolite. This zonation progresses from weakly serpentinized ultramafic rocks, via magmetite/spinel enriched serpentinite, weakly carbonated serpentinite, through carbonate to talc-carbonate rocks. Perhaps significant is the absence of quartz from alteration assemblages.

Although chemical results from the 1988 sampling are not yet available, samples of hydrothermally altered ultramafic rocks in that segment of the Betts Cove ophiolite north of Betts Big Pond collected by Tom Al in 1987, gave sporadic values of up to 310 ppb Pd and 40 ppb Pt, indicating that the process of hydrothermal PGE enrichment has operated in the Betts Cove ophiolite. It should be clarified, that this hydrothermal enrichment of PGE is distinct from the shear-zone related and vein gold mineralization that has been investigated by Al (1988) and Lavigne (1988) in the northern segment and by Hudson (1988) in the southern segment of the Betts Cove ophiolite as part of the Metellogeny of Newfoundland Ophiolites Project.

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GEOCHEMISTRY / GEOPHYSICS

THE REGIONAL DISTRIBUTION OF GOLD AND RELATED ELEMENTS IN LAKE SEDIMENT IN NEWFOUNDLAND

by

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Geochemistry and Geophysics Section

The distributions of Au and related elements such as Sb and As in organic lake sediment not only reflect the majority of known gold occurrences in Newfoundland, but also delineate new areas and geological environments with gold potential, thereby providing new exploration targets. Lake sediment samples had been collected throughout the island of Newfoundland at an average density of 1 site per 7 km2 between 1973 and 1982. These regional surveys were conducted primarily to assess base-metal and uranium potential, and the samples were initially analysed for Ag, Co, Cu, F, Fe, Mn, Mo, Ni, Pb, U and Zn, together with LOI (loss on ignition) as a measure of their organic carbon content.

Orientation studies to determine the nature and extent of geochemical dispersion from several gold prospects and deposits into lake sediment were carried out by McConnell (1987), and an evaluation of suitable commercially available methods for the determination of gold in lake sediment at levels low enough to detect dispersion patterns was made by Davenport (1988). These studies demonstrated that measurable dispersion patterns of Au and other elements, such as Sb and As present in gold mineralization are found in organic sediments from lakes near mineralization. Although the Au anomalies are subtle and low in absolute magnitude, a non-destructive, multi-element analytical method is available commercially, that is capable of adequately measuring the Au abundances, and also those of several important pathfinder elements.

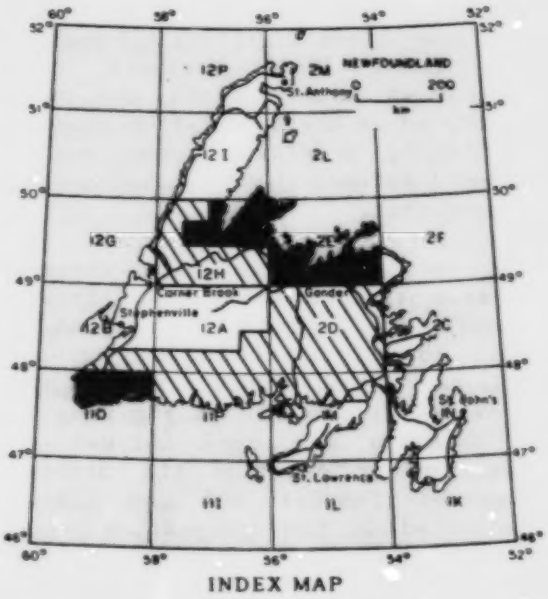

Figure 1: Index map showing areas from which archived regional lake sediment samples have been analysed for gold and related elements: the solid black areas are those for which the data have been released on open file; for the cross-hatched areas, the data will be open filed by the end of 1988.

To determine how effective the techniques developed in the orientation studies would be in detecting areas of gold mineralization using archived samples, a test was made on these samples from the Port aux Basques and White Bay areas (Figure 1). The existing regional samples were analysed by direct neutron activation for Au, together with As, Ba, Br, Ce, Cr, Cs, Eu, Hf, La, Lu, Na, Rb, Sb, Sc, Se, Sm, Ta, Tb, Th, W and Yb (Davenport and Nolan, 1987;

Davenport and McConnell, 1988). These two areas were chosen because they each contain significant gold mineralization, including the Hope Brook Mine, the Cape Ray Prospects and several significant showings in the Port aux Basques area, and, in the White Bay area, Rambler Mines, together with the Deer Cove, Rattling Brook and Unknown Brook Prospects, and many other significant prospects (cf. Tuach, 1988). Moreover, these two areas also include the areas resampled in the orientation studies, permitting a direct comparison of results between these two independent sample sets.

In the White Bay area, there is a good spatial correlation between anomalous Au in lake sediment and the main gold prospects (Davenport and McConnell, 1988), and there is a very close correspondence in the Sops Arm - Jacksons Arm area between the results for Au, from the archived regional samples and the samples collected in the orientation study. In the Port aux Basques area, however, Au in the regional samples did not reflect either the Hope Brook Deposit or the Cape Ray Prospects, although measurable Au dispersion patterns were observed in the orientation studies over these deposits. This apparent discrepancy is the result of the very limited extent of Au dispersion from these deposits: none of the regional samples lies within the limits of their Au dispersion patterns. The results from the two areas taken together, show both the effectiveness as well as the limitations of lake sediment collected at a sample density of 1 site per 7 km2 to reflect gold mineralization.

In addition to Au, several other elements are relevant to gold exploration, and these can be categorized broadly as those that reflect the mineralization itself (pathfinders), and those that reflect the composition of the host rocks to the mineralization. The host rocks of gold deposits in Newfoundland are varied both in age and composition, and indeed the main common feature of the formation and localization of gold mineralization is fault control of the fluid systems from which they were deposited. These mineralized fault systems are reflected by coincident linear anomalies of elements such as Sb, As, Pb and W in the lake sediment, which reflect the broad-scale metasomatism caused by these pervasive hydrothermal systems. The large extent of these anomalies makes them ideal for defining relatively low-density regional surveys, although, as not all of these hydrothermally active fault systems may be auriferous, they should be interpreted in conjunction with the Au data. Elements such as Ni, Cr, Co, Mo and U provide information on the composition of the bedrock, and where coincident with Au anomalies they indicate the nature of the host rocks of the bedrock gold source.

The distributions of Au and related elements in the archived samples from the White Bay and Port aux Basques areas encouraged the staking of several hundred additional claims, and this work together with the earlier orientation studies of McConnell (1987) have led to the use of lake sediment by the mineral exploration industry for gold exploration. Results released for archived regional samples from the Botwood map area (NTS sheet 2E, Figure 1) also prompted additional claim staking in that area, and of particular significance was the focussing of attention on two geological environments with previously little recognized gold potential, namely the marine clastic rocks of the Davidsville and Indian Islands Groups, and the terrestrial clastic rocks of the Botwood Group.

Table 1. List of open file releases of gold and related elements in archived regional lake sediments in Newfoundland.

	TITLE	NTS	OPEN FILE
1	Gold and associated elements in lake sediment from regional surveys in the Port aux Basques area (NTS 11O) and the White Bay area (NTS 12H/9-11,15,16 and 12I/1).	11O 12H 12I	NFLD 1582
2	Gold and associated elements in lake sediment from regional surveys in the Botwood map area (NTS 2E).	2E	2E/563
3	Gold and associated elements in lake sediment from regional surveys in the Gander map area (NTS 2D).	2D	2D/175
4	Gold and associated elements in lake sediment from regional surveys in the northwestern part of the Belleoram map area (NTS 1M/5,11-16).	1M	1M/276
5	Gold and associated elements in lake sediment from regional surveys in the Burgeo map area (NTS 11P).	11P	11P/137
6	Gold and associated elements in lake sediment from regional surveys in the southwestern part of the Red Indian Lake map area (NTS 12A/1-4,8).	12A	12A/478
7	Gold and associated elements in lake sediment from regional surveys in the southern part of the Stephenville map area (NTS 12B/1-3).	12B	12B/301
8	Gold and associated elements in lake sediment from regional surveys in the Sandy Lake map area (NTS 12H). This open file includes the results released previously for 12H/9-11,15,16 as part of open file NFLD 1582.	12H	12H/1012

Archived samples have been analysed for Au and related elements from NTS map areas 2D, the northwestern part of 1M (1M/5, 11-16), 11P, the southeast part of 12A (12A/1-4,8), the southern part of 12B (12B/1-3), and 12H (Figure 1). The results from these areas will be released on open file by the end of 1988 (see Table 1), and it is planned to extend this program of reanalysis to include all archived regional lake sediment samples in Newfoundland as funding permits.

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GEOCHEMICAL SURVEYS OF LABRADOR WEST

by

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Lake Sediment Data

All the data from detailed geochemical surveys in western Labrador will be made available shortly. The most recent open file [Lab(771)] was released on October 6, 1988. Included with this release are 7 element distribution maps (Au, Ag, As, Cr, Cu, Pb and Sb), a sample location map, a summary report and a data listing. The data listing includes the analytical results for the elements plotted, as well as the elements analysed for, by the multi-element neutron activation delayed counting technique (Ba, Br, Ce, Cs, Eu, Hf, La, Lu, Rb, Sc, Se, Sm, Na, Ta, Tb, Th, W, U, Yb and Zr) and from analysis by AA (Cd, Co, Fe, Mn, Mo, Ni, Zn and loss on ignition). The field data for each sample is also included.

The data is presented as a series of contoured maps, plotted on a topographic and geologic base map. The contour interval was determined by examination of the cumulative frequency plots for each element.

Several interesting anomalies lie within the Howell's River area. The multi-point Howell Lake Au anomaly being the most interesting. However, there are anomalies to the south which coincide with other elements and underlain by a different geology that warrant equal attention. A Pb anomaly to the west of Kivivic Lake also has Ag associated with it. This survey also showed that As is not a good pathfinder element for Au in this area.

Stream Sediment and Soil Survey Data

Stream sediment samples and soil samples collected in the Howell's River area are presently being reviewed and will be released on open file by the end of this year.

LAKE SEDIMENT AND WATER GEOCHEMICAL SURVEYS FOR RARE METAL MINERALIZATION IN LABRADOR

by

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Introduction

This paper is a brief summary of a recently released report (McConnell, 1988), of a study conducted during 1983 and 1985 following the discovery of the Strange Lake (Lac Brisson) rare-metal deposit in western Labrador. This type of deposit is receiving increasing exploration attention by industry, with the expectation that the demand for this commodity will increase rapidly.

The study undertook to characterize the nature of geochemical dispersion into the surficial environment, and paid particular attention to the role of lake sediment and water geochemistry. Two areas were sampled in the vicinities of Strange Lake and Letitia Lake in which rare-metal mineralization is present. A 50 million tonne deposit of Zr-Y-Be-Nb-REE is contained within an alkaline intrusion at Strange Lake (Miller, 1988). Several smaller Nb-Be and Zr occurrences are located in the Letitia area, generally in association with peralkaline rocks (Miller, 1988). The Letitia area has anomalous levels of F and Zn (Geological Survey of Canada, 1983). The two other areas studied, referred to here as Michikamats and '13L', were not known to be mineralized but were surveyed because the occurrence of very high levels of F in the reconnaissance data (Geological Survey of Canada, 1978 and 1983) suggested the presence of specialized or possibly mineralized granitoids. The locations of these four areas is shown in Figure 1.

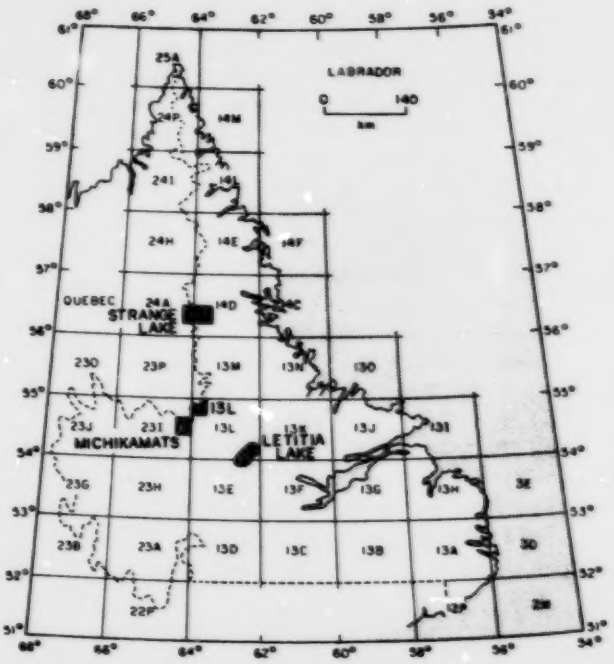

Figure 1: Location of survey areas.

High density lake sampling (1 site per 4.7 km2) was done to further assess the mineral potential of these areas and to determine whether elements not previously analysed in sediment would prove useful as guides to mineralization. Sediment samples were analyzed for F and loss on ignition, and by atomic absorption (AA) for Ag, Be, Co, Cu, Fe, Mn, Mo, Ni, Pb and Zn. In addition the survey took advantage of recent advances in analytical technology (viz. inductively coupled plasma emission spectrophotometry and, at Strange Lake, direct neutron activation) to obtain analyses of more than 40 elements including several rare-earth and possibly ore-related elements associated with granites such as Au,

Ce, Eu, Hf, La, Lu, Nb, Sm, Ta, Tb, Th, U, W, Y, Yb and Zr.

Water samples from all areas were analyzed for pH and F. Waters from the Letitia area were analyzed for Y by ICP and for Zn by AA. Waters from the Strange Lake area were analyzed for U by neutron activation.

Results

Previous reports have discussed the geology and mineralization (Miller, 1988), Quaternary geology (Batterson et al., 1985 and 1986) and the nature of stream sediment, stream water, till and preliminary lake sediment geochemistry (McConnell and Batterson, 1987) in some of the areas.

The data in the current report were subjected to a variety of procedures in order to obtain statistics for area comparisons, to identify environmental influences and element correlations, to separate component geochemical populations and to recognize groups of elements and anomalous concentration levels associated with mineralization. These procedures include the computation of basic statistics (means, standard deviations, ranges, etc.), histograms, cumulative frequency plots, pearson correlations, regression analysis, principal components analysis and plotting of contoured data maps. From these the following observations are drawn:

(1) Many elements in the rare-metal suite (e.g., Be, Hf, Nb, REE, Zr, Y) are present in lake sediment and derived from mineralized areas, in concentrations that are considerably higher than those in lake sediment from non-mineralized areas.

(2) In the Strange Lake area, Y, Be, the heavy rare earths, Th, Zr, Pb and ratios of HREE/LREE in lake sediment are particularly effective in reflecting the mineralization. Fluoride in water distinguishes the peralkaline intrusion. Water samples from the Strange Lake area had less than detection limit concentrations (10 ppb) of Be, despite their proximity to Be mineralization. A contour map of Yb distribution (Figure 2) illustrates

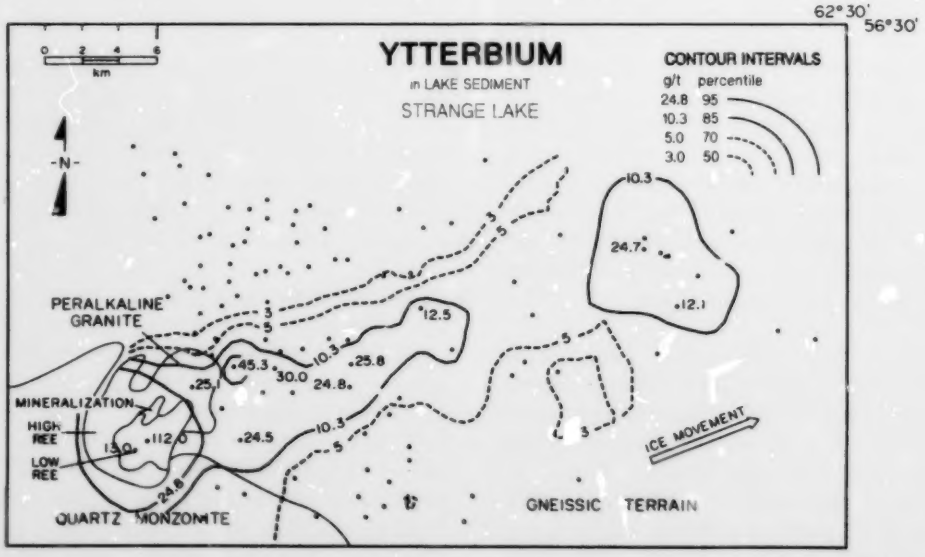

Figure 2: Contour map of ytterbium in lake sediment, Strange Lake area.

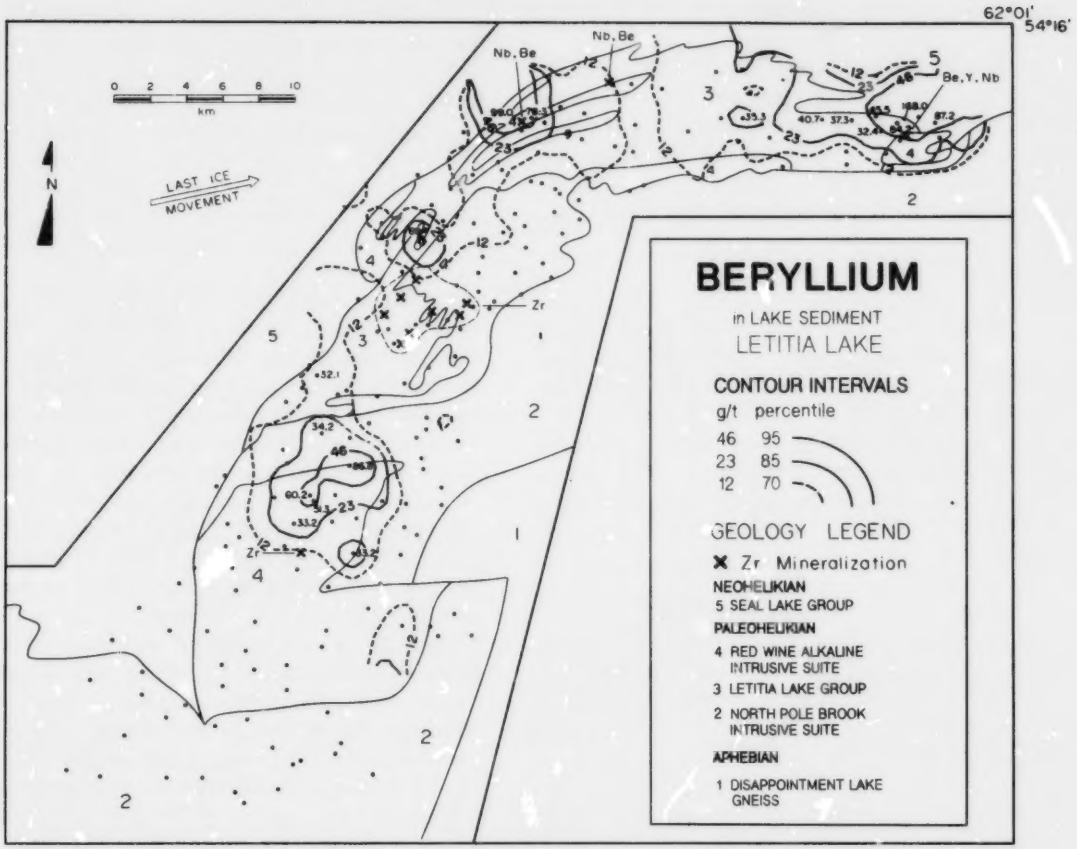

Figure 3: Contour map of beryllium in lake sediment, Letitia Lake area.

the elongate dispersion pattern typical of HREE that extends down-ice from the deposit. Principal components analysis yields a factor which is composed of several of the elements associated with the deposit. A plot of the distribution of scores of this factor clearly focuses on the mineralized area.

(3) In the Letitia Lake area, the Mann and Two Tom Lake rare-metal occurrences are identified in lake sediment by Zn and Be and, to a lesser degree, by Nb. Zinc, Y and F in lake waters, also highlight the mineralized areas. In addition, unexplored areas are identified that have Zn, Be, Zr and Nb lake sediment anomalies of equal intensity to those in proximity to mineralization. A contour map of Be distribution (Figure 3) shows the relationship of Be anomalies to geology and known mineral occurrences.

(4) In the Michikamats area, there are anomalies in F, Ce and La similar in magnitude to those associated with mineralization at Strange Lake and Letitia Lake. However, the concentrations of the elements Y, Nb and Be are substantially lower than in the mineralized areas. No HREE data are available for this area but since the chemical behaviour of HREE is similar

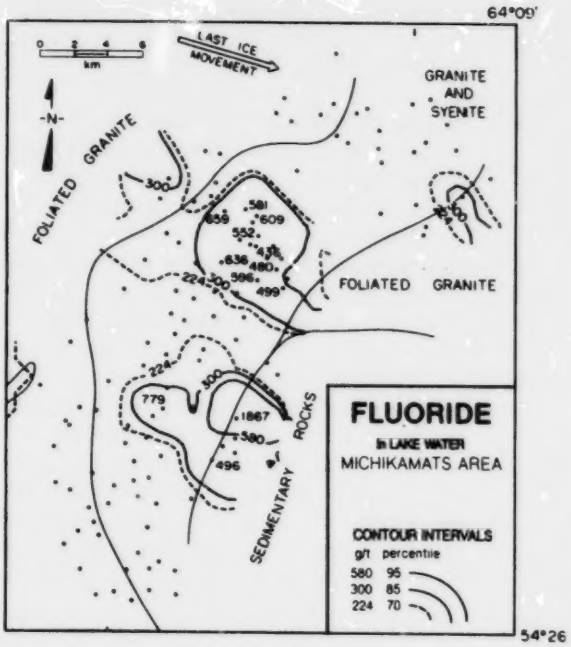

Figure 4: Contour map of fluoride in lake water, Michikamats area.

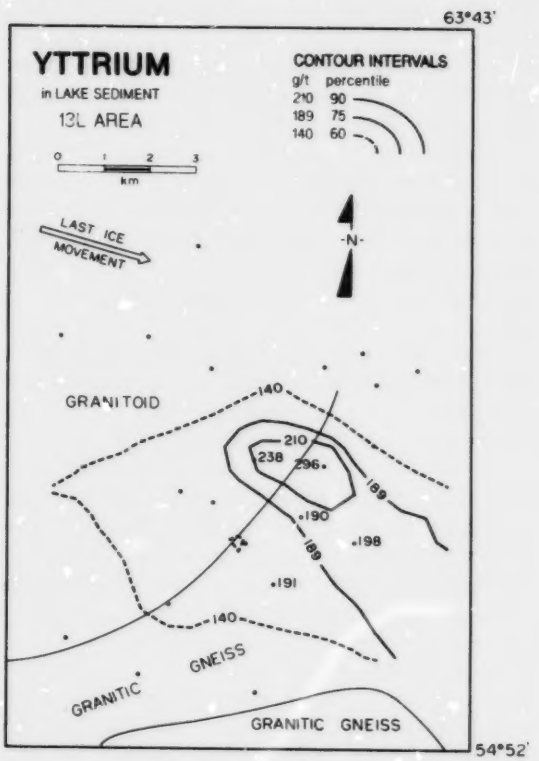

Figure 5: Contour map of yttrium in lake sediment, '13L' area.

to that of Y, levels are likely not high. The contour map of F in water (Figure 4) shows two centres of high concentrations, a pattern which is similar to those of Be, Y and La.

(5) In the fourth area, '13L', there are anomalies in Y and F of similar magnitude to those derived from mineralization at the Letitia and Strange Lake areas. The distribution of Y is illustrated in Figure 5. Levels of Be and Ce are also high, whereas Zr and Nb values are not.

(6) Erosion, transport and deposition during continental glaciation in the Strange Lake area produced a geochemical fan identifiable 40 km down-ice from the deposit. Element values generally, but not always, increase toward the up-ice origin. By contrast, glacial smearing is much less evident in the other three areas with maximum anomaly displacement from source being between 2 and 4 km.

Conclusions

(1) Lake sediment and water geochemistry provide effective prospecting methods for rare-metal mineralization in Labrador.

(2) Several elements may be useful depending on the source mineralogy. In sediment these include Be, F, Hf, Nb, Pb, REE, Th, Y, Zn and Zr. In water they comprise F, Y and Zn.

(3) Analyses by ICP and direct neutron activation provide data for several elements of interest to rare-metal exploration.

(4) Principal components analysis is a useful technique for recognizing element associations diagnostic of rare-metal mineralization. This is

particularly useful in areas where knowledge of the chemical character of mineralization is lacking.

(5) Environmental factors encountered within the lake such as organic content (LOI), pH of water, and adsorption by Fe and Mn oxides do not appear to have a large influence on the distribution of REE in lake sediment. The distributions of F, Hf, Nb and Zr, on the other hand, have moderate to strong negative correlations with LOI in most areas. The interpretation of dispersion patterns of such elements may be enhanced by the use of regression analysis to calculate residual values.

(6) The shape and areal extent of geochemical dispersion fans vary broadly and are products of the erosional and depositional regimes active during glaciation.

(7) Several unexplained anomalies are present in areas which have received little or no exploration in the Letitia Lake, Michikamats and '13L' areas. These targets are potential sites of undiscovered rare-metal mineralization.

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DATAFILE MANAGEMENT

by

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Since the initiation of the Federal-Provincial Geoscience programs in 1972, there has been a large volume of geochemical data collected, by the various projects. Both the field information and the analytical data from these projects are stored on magnetic tape at the Newfoundland and Labrador Computer Services facilities in St. John's. Over the past year an attempt has been made to organize the data into standardized files and to make it publicly available.

Granite File

The development of the Newfoundland granite file has progressed well over the past year. A copy of the granite information has been created on a single file, with standardized formats and variable names. However, a number of refinements still need to be made to the present file, before it can be made available as an open file.

The present file contains approximately 4000 cases with 80 variables. About 33 of these variables concern field information, such as location, sample type and rock name. The remaining variables are concentrations of major oxides and trace elements. No norms or calculable ratios, etc., are included on the file. The data on this file can be retrieved by either the pluton or the NTS sheet number, either on a 1:250,000 or 1:50,000 scale. The data is presently stored on disk on the HP9000 minicomputer as an SPSSX file. It can be written out to a magnetic tape, or floppy disk in a variety of formats including ASCII.

Other Data Files

There has been a considerable amount of cleaning and reorganization done on the lake sediment data files. All data for Ag, Co, Cu, F, Fe, Mo, Mn, Ni, Pb, U, Zn and loss on ignition for all reconnaissance samples collected between 1973 and 1981 are available on floppy disk. The data is presently divided into files based on the 1:250,000 NTS sheet number. In addition, as new data is released it is also made available as an ASCII file on 5.25 inch floppy disks containing the field and analytical data. These files have recently become available on 3.5 inch disks.

No work has been done on the stream sediment and soil data which are presently on file. It is intended, however, as with the lake sediment data, to clean up these files and release them as open files. When any new stream or soil data is made public, an ASCII file of the data will also be made available on disk.

GRAPHICAL DISPLAY OF SPATIAL GEOCHEMICAL AND GEOPHYSICAL DATA

by

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Software Developments (for contouring and geological mapping)

Two U.S. Geological Survey programs, GSDRAW and GSMAP, have been set up for the digitizer and plotters in the computer unit. The programs enable geoscientists to digitize geological and topographical information into a microcomputer database which can be plotted as maps and diagrams at varying scales and projections. The plotting parameters include common geological symbols and line types that can be plotted at publication quality, and edited or updated.

A microcomputer program has been developed to plot cumulative frequency distributions of geochemical data from SPSS data files. It is planned to expand this program from the present limitation of only plotting the graph to enhancing the screen display and inflection-point analysis. The primary use of the cumulative frequency plot is to aid in determining population breaks in a data set for selection of contour intervals.

Spatial Analysis System

A proposal has been prepared to acquire a microcomputer-based system to carry out image analysis and overlaying of distinct sets of spatial geoscientific data which will function as a geographic information system for these data. This system will aid geologists in the interpretation and display of geochemical, geological and geophysical data structures individually and in complex multiple data sets. The system will permit image/spatial analysis combined with a publication quality plotting.

AEROMAGNETIC TOTAL FIELD/GRADIOMETER, VLF SURVEY CENTRAL NEWFOUNDLAND 1986/87

by

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Under the Canada-Newfoundland Mineral Development Agreement, an aeromagnetic total field/gradiometer and VLF survey was carried out over an area within the Dunnage Zone of central Newfoundland. A sketch of the survey location is shown in Figure 1. The complexity of the basement in this area is such that its structural and compositional changes have a definite magnetic signature, making indirect geological mapping through aeromagnetics very successful.

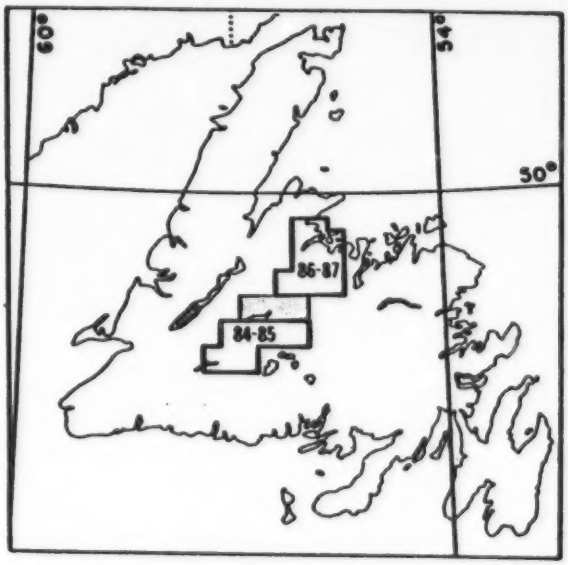

Figure 1: Resolution Aeromagnetic Total Field/Gradiometer and VLF Survey 1986/87 - Central Newfoundland. Shaded area is GSC Queenair survey done in 1983.

The contract was awarded to Aerodat Limited of Toronto and the survey was flown between November 1986 and August 1987, using a rotary wing aircraft. Two Cesium vapour magnetometers, each with a resolution of .002 nanoteslas and separated by 3 m, measured the gradient field. VLF total field and vertical quadrature components were recorded with a Herz Totem-2A receiver, using the Annapolis, Maryland transmitter signal. A mean elevation clearance of 150 m was maintained with a flight line separation of 300 m and a control line separation of 5 kilometres.

Survey results are available at two map scales: 1:25,000 aeromagnetic total field and gradiometer contour maps and 1:50,000 magnetic anomaly and gradiometer colour interval maps. The VLF total field and quadrature profiles are printed on the back of the magnetic anomaly and gradiometer colour interval maps respectively. This presentation provides a means to view the VLF data jointly with the magnetics through the use of a light table.

In the central Newfoundland survey area, the magnetic signature not only confirms mapped geology (Dean, 1975), but also provides additional details. A number of structural features stand out clearly on the gradiometer colour maps. Several phases of plutonic intrusion have occurred in the southern part of the survey area and these are transected by more recent northeast striking faults. A folded swarm of sills intrudes further to the north. Near the top of the survey area there is evidence of a thrust sheet. Although, all of these features have been previously identified, the specific information on each is enhanced by the geophysical results.

The igneous intrusions are of Devonian age (Dean, 1975) and are graphically outlined by the magnetics and less so by the VLF-EM. The contacts of the Hodges Hill, Topsails and Dawes Pond granites as well as the Twin Lakes Diorite Complex are particularly well defined. The gradiometer trace is effective for this purpose as the zero gradiometer contour tends to lie directly above a magnetic contact in northern latitudes. For Newfoundland, this contour will be slightly offset due to the inclination of the earth's field, the effect of remanent magnetization and the interference from adjacent sources. VLF anomalies are associated with both contrasts in conductivity between rock units and cultural features.

In the north, the ophiolitic rocks of the Lushs Bight Group are thrust faulted against the Silurian Springdale and Ordovician Roberts Arm Groups (Kean, 1984). The magnetics trace this fault (Lobster Cove Fault) very clearly where the basaltic pillow lavas are thrust against the Roberts Arm Group to the south.

Middle and Lower Ordovician diabase and gabbro sills intrude the Wild Bight Group southwest of Badger Bay. The contrast in magnetic response between these units is such that folding patterns can be readily traced. The vertical gradient indicates that the number and extent of these folded, north-northeasterly trending units is far greater than currently identified from field mapping.

North of the Topsails granite, along the western edge of the survey area, the volcanics of the Silurian Springdale Group are alternately acidic and mafic units. The different magnetic signature of each of these units helps define the Burnt Berry syncline which trends to the northeast.

A post-Devonian period of major faulting is clearly defined by the magnetic data. These east-northeasterly faults such as Northern Arm, Long Pond and Four Mile show up clearly, particularly where they cross magnetic features at almost right angles. Several previously mapped faults can be extended or modified on the basis of this new information.

Funds for this project were provided by the Geological Survey of Canada, under the Canada-Newfoundland Mineral Development Agreement 1984-1989. The digitized data can be purchased from the Geophysical Data Centre, Geological Survey of Canada, 1 Observatory Crescent, Ottawa, Ontario, K1A 0Y3 (telephone: (613) 992-6438) for further processing and interpretation.

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GEOPHYSICAL INVESTIGATIONS IN EAST CENTRAL NEWFOUNDLAND

by

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Geophysical investigations carried out during 1987-88 may be categorized as: 1) studies involving regional geophysical datasets and 2) detailed ground follow-up surveys, designed to address questions of a local nature, but having regional applications.

Regional Studies

A project was initiated in late 1987 with the objective of manipulating and displaying Geological Survey of Canada airborne magnetic, gradiometer and VLF-EM datasets covering volcanic and sedimentary rocks of the Victoria Lake Group near Buchans (Region 1, Figure 1). The southern part of this survey (i.e., the Victoria Lake (12A/6) and Showshoe Pond (12A/7, west half) map areas was selected as the focus of this pilot study, for reasons of concurrent mapping, the variety of geological units represented and its mineral potential.

Aeromagnetic and gradiometer datasets were pre-processed via the Department's mini-computer system, transferred to digital tape and loaded onto the Dipix Aries III image analysis system at NORDCO Ltd. for display and hard-copy output. Digital processing consisted of IGRF removal from the aeromagnetic data, variable false sun angle shaded relief, and calculated first and second vertical derivatives.

Directional filters of varying angles of false illumination were applied to the total field magnetic (IGRF removed) and vertical gradient datasets to optimally enhance their subtle features. The various calculated gradient maps (first and second derivatives), and the gradiometric data themselves, were shown to be valuable interpretive tools in tracing the boundaries of bedrock lithologies, particularly in areas of overburden. However, a series of shaded-relief, colour aeromagnetic maps proved to be of greater value, as an interpretional aid to the geologist or geophysicist. First-order interpretation of characteristic magnetic signatures, such as those expressed by volcanogenic sediments, nearly homogeneous plutonic rocks and large-scale flexures, correspond to those identified on the surface. In addition, several small-scale or subtler features are enhanced by specific illumination directions. Among these are foliation orientations within plutonic bodies and a series of large-scale, late-stage, northwest-southeast oriented fractures not readily detected on the surface. The latter features are of interest because of their relation to gold and massive sulphide mineralization within the Victoria Lake Group.

Various combinations of enhanced datasets were superimposed directly on a Dipix Aries III system screen in attempts to glean additional information. However, a methodology for combining the various datasets directly has, as yet, not been developed. The VLF-EM quadrature and total field datasets have not been incorporated into the study. Since each data type expresses a different characteristic of surface rocks, the potential existing in the proper combinations of these regional datasets remains relatively untapped.

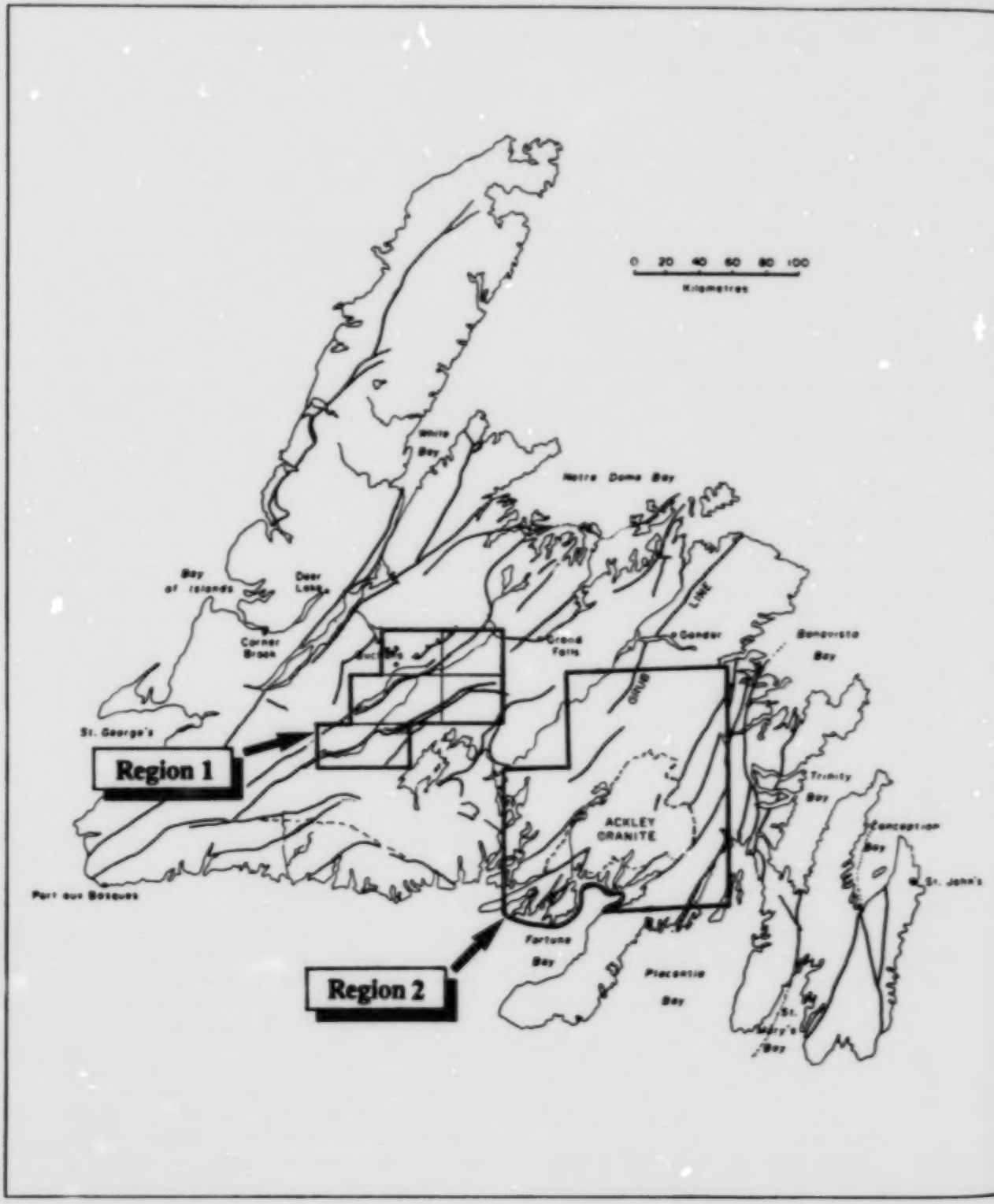

Figure 1: Locations of regional geophysical studies in Central Newfoundland. Major faults and lineaments are added for reference.

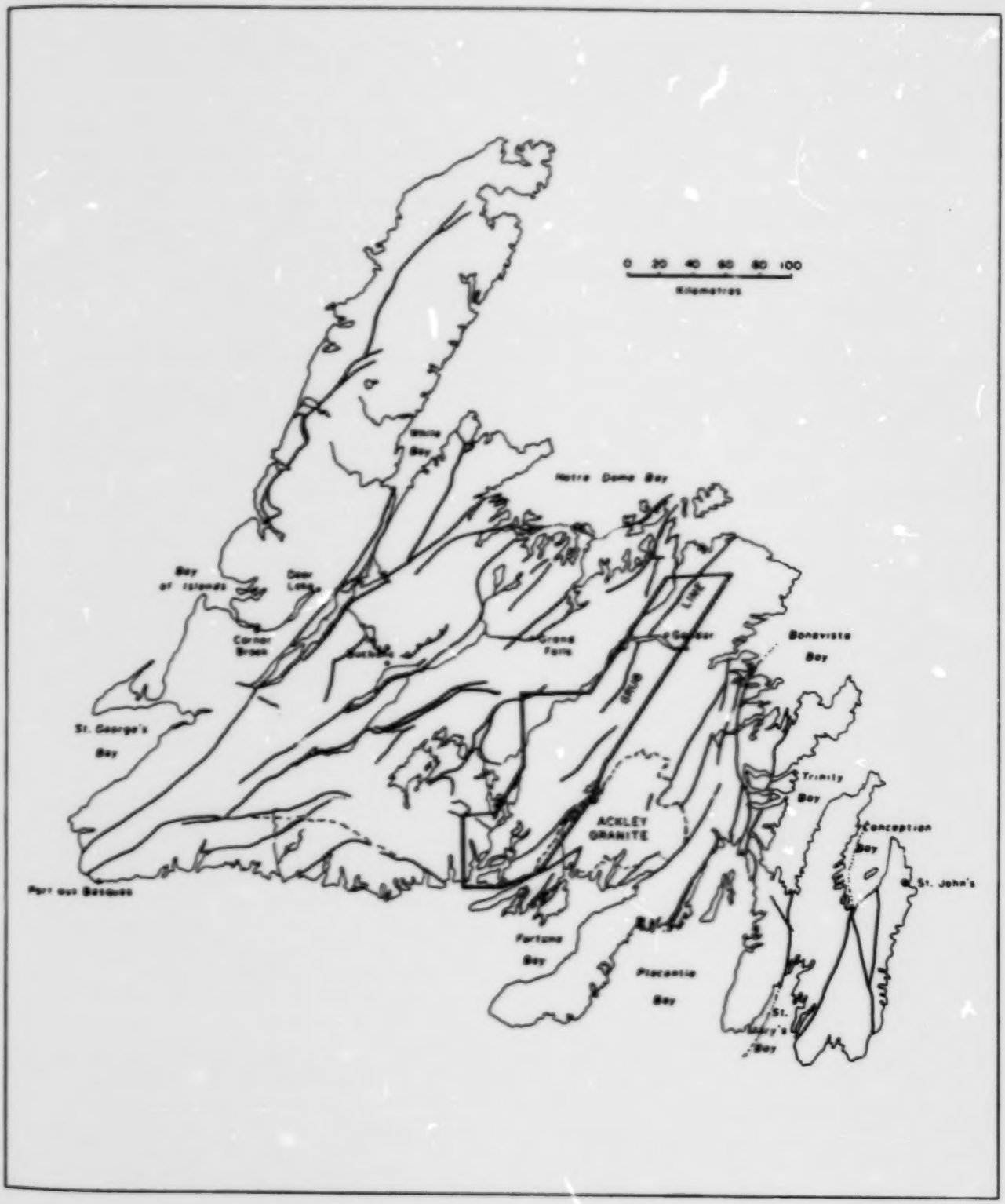

Figure 2: Locations in East-Central Newfoundland of detailed geophysical surveys conducted during the 1988 field season.

Recently, the manipulation and display of VLF-EM data from the Geological Survey of Canada Skyvan survey of South-Central Newfoundland (Region 2, Figure 1) has commenced. Colour profile plots of VLF quadrature, total field and Fraser-filtered quadrature values have been produced. Aside from cultural features and the conductive coastline anomalies due to salt water, several conductive lithologies have been identified. Of particular interest are a large conductor beneath Gander Lake, coherent conductors within the Ackley Granite, and those within St. Joseph's Cove Formation (Dickson, 1986) of the Baie d'Espoir Group, in an area of extensive overburden.

Detailed Surveys

Much of the 1988 field season was devoted to surveys of magnetically anomalous lenticular mafic and ultramafic bodies for two reasons: i) their magnetic contrast is sufficiently large relative to host rocks, to enable accurate modelling of their subsurface geometries; and ii) their occurrence frequently coincides with major lithostratigraphic boundaries.

The boundary between the Gander and Dunnage zones has gained importance, in light of the recent subdivision of tectonic elements in Central Newfoundland (Williams et al., 1988). One interpretation has the Dunnage rocks thrust over the Gander Zone, undergoing further deformation, and intruded by granitoids (Colman and Swinden, 1984). Thus, the tectonic window represented by the Tim Horton Complex is merely a localized high in the Gander-Dunnage interface, which subsequent to erosion, exposed Gander Group rocks in its centre. If this theory holds, ultramafic rocks, providing the lubrication at the interface, should exhibit specific and predictable orientations with depth. With sufficiently detailed magnetic measurements over these units to constrain modelling, the theory can be tested.

Ultramafic rock units at or near the contact between the Gander and Davidsville/Baie D'Espoir Groups were investigated during the 1988 field season. Profiles were recorded in several localities throughout the belt of rocks near the contact from north of Gander to east of St. Alban's (Figure 2).

Highlights of the 1988 Field Season

- In the Weir's Pond (2E/1) map area, geophysical traverses were established over recently mapped gabbro and ultramafic rock within Gander Group sediments (O'Neill, 1987) and adjacent magnetic anomalies. Modelling of magnetic data may shed light on the source of a major magnetic anomaly through the central Gander Group units. The magnetic susceptibilities of all available rock samples for the Weir's Pond map area have been measured and contoured to aid the interpretation of the aeromagnetic map.

- A bifurcating magnetic anomaly pattern at the southern end of exposed units of the GRUB was investigated. Magnetic modelling may elucidate the nature of this pattern and its relation to a repetitive anomaly pattern observed elsewhere across the breadth of the GRUB (Kilfoil, 1988).

- Lenticular ultramafic and mafic outcrops have been identified on both the northwest and southeast margins of the Middle Ridge Granite (Blackwood, 1983). Detailed profiles were positioned over these units to determine their subsurface orientations on either side, and to compare the

geometry with that of the Tim Horton Complex. Traverses were positioned over a series of magnetic bodies extending southwest from north of Newton Lake, a northeast continuation of the ultramafic lenses investigated in 1987 within the Mount Sylvester (2D/3) map area (Kilfoil, 1988). On the northwest margin of the Middle Ridge Granite, several traverses were established, transverse to an elongate magnetic anomaly arising from serpentinite which is exposed southwest of Little Gander Pond.

- Magnetic anomalies were followed in the Twillick Brook (2D/4) map area as a southwest extension of the ultramafic rocks, which outcrop in the Mount Sylvester map area. Although no anomalous magnetic rocks were observed in exposure, their presence is suspected at depth, and may define a "hidden thrust zone" as depicted in a lineament map by Tuach (1987).

- Profiles were obtained across the extensive ultramafic complex known as the Great Bend ophiolite, located on the east flank of the Tim Horton Complex. Magnetic modelling, constrained by recent geological mapping (Zwicker and Strong, 1986) and aeromagnetic data, should delineate the subsurface orientation of the ultramafic units, which may have implications for their mode of emplacement and their relationship in the regional tectonic framework.

- Magnetic/VLF profiles were established over aeromagnetic anomalies coincident with recently mapped ultramafic rocks on the northwestern edge of the Tim Horton Complex in the Miguels Lake (2D/12) map area. These anomalies coincide with the contact between Gander Zone rocks to the southeast and Silurian aged units to the northwest of the Botwood Group (Colman-Sadd, pers. comm.).

- A distinctive aeromagnetic anomaly coincident with exposed altered pyroxenite southwest of Long Pond in the St. Alban's (1M/13) map area (Colman-Sadd, 1986) can be traced around the northeast end of the North Bay Granite to its southeastern margin. Ultramafic rocks were located to the east, during geophysical follow-up of this anomaly. Modelling studies should determine the disposition of ultramafic rocks relative to the pluton, and to similar units elsewhere.

- Follow-up surveys were also established over magnetic anomalies associated with magnesite occurring proximal to shear zones in Hungry Grove Pond (1M/14) and D'Espoir Brook (11P/16) map areas (Dickson, 1987; Dicksn and Tomlin, 1983).

Although ultramafic rocks do not everywhere define the transition between the Gander - Davidsville/Baie d'Espoir lithotectonic units, they occur with sufficient frequency at the boundary that one should suspect a transition,proximal to their occurrence. Locally, magnetic anomalies associated with ultramafic rocks are arranged in a ring surrounding outcrop of either Gander Group rocks (Tim Horton Complex) or late-stage granitic intrusions (Middle Ridge Granite). The implications of these features are that anomalously magnetic ultramafic rocks are outlining windows through rocks of the Dunnage Zone. Through constrained magnetic modelling of the detailed profiles obtained throughout the GRUB - Bay d'Espoir belt, an improved under-

standing of the inter-relationship between the tectonic elements comprising the belt will emerge.

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QUATERNARY GEOLOGY

QUATERNARY MAPPING IN LABRADOR

by

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Introduction

Quaternary mapping in Labrador has been as ongoing contribution to the Canada-Newfoundland Mineral Development Agreement (Batterson et al. 1985; Batterson and LeGrow, 1986; Batterson et al. 1987; Batterson et al. 1988). The program aims to assist mineral exploration in the area through the provision of background data on ice flow directions, their chronology and effects on the distribution and characteristics of glacial sediments, through a combination of field, laboratory and office work.

Field Component

To date, field work has concentrated on the Strange Lake area of Northern Labrador and 3 areas in the Central Mineral Belt: the Letitia Lake (13L/1 and part of 13L/8), Melody Lake (13J/12 and 13K/9) and Moran Lake (13K/10 and 13K/7) areas. Each of these areas has been, or is an area of mineral exploration activity. Mapping has involved terrain identification with the aid of aerial photography and landsat imagery, determination of paleo ice flow directions using both erosional and depositional evidence, and the types and distribution of glacigenic sediments. Dispersal studies, designed to characterize the effects of glacier ice on the erosion, transportation and deposition of material, utilized visually distinctive and aerially discrete indicator lithologies. Glacigenic sediments were sampled to determine grain size characteristics and the geochemical response of individual sediment types, as an aid to determining their suitability in mineral exploration programs.

Laboratory Component

Grain size analysis included, sieving of the coarser than 0.063 mm fraction and Coulter Counter analysis of the silt/clay fraction. The silt/clay fraction was also analysed for Be, Cd, Co, Cu, Fe, Li, Mn, Mo, Ni, Pb and Zn by atomic adsorption spectrophotometry; Ba, Ce, Cr, Ga, La, Nb, Rb, Sr, Th, V, Y and Zr by ICP; and U by delayed neutron activation. This geochemical data will be released before the end of 1988.

Additional programs have involved the compilation and statistical manipulation of geochemical data, the production of surficial geological maps and the composition of reports. This program is ongoing, and was the major focus of efforts during the summer of 1988.

Mineral Exploration Implications

Despite the incomplete nature of individual reports, several general comments can be made:

1) The well defined geochemical and lithologic dispersal trains from the Strange Lake complex in northern Labrador are not a representative feature of dispersal throughout Labrador. The Strange Lake area is on a plateau surface and has been subjected to one dominant glacial regime. In contrast, areas in the Central Mineral Belt are within areas of dissected topography and have been

affected by at least 3 periods of glacial activity. As such, dispersal patterns are more varied.

2) Geochemical response varies between sediment types within the same area. While this is not a new conclusion, it does emphasises that consistency of sediment type used in geochemical surveys must by maintained.

3) Even within the same sediment type and within the same area, variations in dispersal patterns have been determined and are a response to the interaction of different glacial flow events. This is particularly the case towards the margins of the Laurentide ice sheet in coastal areas, where the last phase of ice flow was commonly confined to valleys, whereas previous ice flow events were not topographically constrained.

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SOUTH COAST NEWFOUNDLAND QUATERNARY MAPPING - AN UPDATE

by

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Background

Mapping was conducted during 1985 and 1986 in the Peter Snout (11P/13), King George IV Lake (12A/4), La Poile (110/9) and La Poile River (110/16) map areas of southwestern Newfoundland. Eleven hundred and thirty-six matrix samples were collected from the 'C' soil horizon in streamlined and hummocky landforms. Samples were obtained from drumlins, crag and tail hills, ramps, hummocks, eskers and in featureless areas covered by a thin veneer of glacial sediment (commonly till). A representative pebble fraction (16 to 60 mm) was obtained at approximately 450 sites and the pebble types were determined and referenced to bedrock map units.

Geochemical Analysis

The 63 micron fraction (-250 mesh) of the matrix samples have been analyzed for Cu, Pb, Zn, Co, Ni, Mn and Fe by atomic-absorption spectroscopy, Au by fire assay and delayed counting neutron activation and U by neutron activation. The finer than 63 micron fraction was chosen for geochemical analyses because of the relative ease of sample preparation in comparison to obtaining the clay fraction by centrifuging.

Particle Size Analyses

The minus -8 mm fraction of the samples have been analyzed for particle size distribution from 4 mm to 0.00126 mm. The procedure involves both mechanical sieving through a bank of sieves and an electronic size analysis using a fine particle analyser (Coulter counter).

Preliminary Results and Conclusions

1) Construction and erosional landforms in this area of southern Newfoundland were probably created during a southward advance of ice that extended to at least the coast.

2) Deposition of glacial sediments was not extensive.

3) Most depositional landforms were formed subglacially.

4) Transport distance for most pebble-size fragments is less than 10 km.

5) The presence of Au in till is weakly positively (.34) correlated with the occurrence of Victoria Lake Group clasts in till (King George IV Lake map area).

6) Mean geochemical values for Cu are highest in hummocky terrain.

7) Mean geochemical values for Pb are highest in areas with no constructional forms (till blanket or veneer) and lowest in streamlined forms (drumlins, flutes, crag and tail hills, ramps).

8) Values for Pb, Zn and Co are lowest in streamlined forms.

9) Preliminary analysis of the distribution of pebble lithologies, indicate that the hummocky deposits are composed of material that is transported further than that in other landform types.

Implications for Drift Exploration

- One southward ice-flow predominated and therefore the interpretation of geochemical anomalies in drift is not complicated by multi-directional glacial dispersion.

- The subglacially deposited landforms throughout the area provide an optimal sampling media because the sediment is commonly of a local origin.

- The differing geochemical characteristics of landforms should be considered in interpretation of soil or till anomalies where the sampling area includes several landform types.

- Pebble lithology is an important consideration when interpreting soil or till anomalies because it provides useful information with respect to source.

Publications to Date

1) Quaternary Mapping La Poile (110/9) and La Poile River (110/16) map areas, southwestern Newfoundland. In Current Research. Newfoundland Department of Mines, Mineral Development Division, Report 87-1, pages 23-30.

2) Landform Classification Maps: La Poile; La Poile River; Peter Snout; and King George IV Lake map areas, Newfoundland. Newfoundland Department of Mines, Mineral Development Division, Open File NFLD 1574.

3) Surficial and Glacial Mapping - Peter Snout (11P/13) and King George IV Lake (12A/4) map areas, southwestern Newfoundland. In Current Research. Newfoundland Department of Mines, Mineral Development Division, Report 86-1, pages 283-289.

QUATERNARY GEOLOGY OF THE BAIE VERTE PENINSULA

by

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Introduction

The Baie Verte peninsula, located in north-central Newfoundland, is an area of considerable interest with regard to mineral exploration. Historically, it has been the site of mines since 1864, with active mining for copper, silver and gold up until 1982 (Hibbard 1983). In 1988, numerous exploration crews from various mining concerns were active on the peninsula, with gold being the primary target. Exploration techniques include soil sampling and boulder tracing which require a good understanding of the regional glacial history. However, the ice flows history and genesis of surficial sediment on the peninsula is poorly understood. This project was initiated in order to better define the Quaternary geology of the area, which may help to improve the efficiency and effectiveness of drift exploration.

Location of the Study Area

The study area is similar to that of Hibbard (1983), bounded by the Trans-Canada highway to the south, Green Bay to the east, and White Bay to the west. This encompasses all of four 1:50,000 map sheets (2E/14, 12H/15, 12I/1, and 2L/4) and parts of 7 others (2E/5, 2E/12, 12H/7, 12H/8, 12H/9, 12H/10 and 12H/15).

Previous Work

Early work is summarised by Hibbard (1983), who also provided a comprehensive survey of the bedrock geology. Lundquist (1965) examined striae in the area and suggested that major ice flow was from the south-west to north-east over the peninsula. As deglaciation progressed, local topography became increasingly important and gave rise to considerable variation in flow direction. Tucker (1973, 1974) worked to the south of the field area, as did Alley and Slatt (1975). These detailed studies generally support the ice flow history of Lundquist (1965). The area has been mapped on a reconnaissance level by Grant (1986), largely by aerial photograph interpretation, but with some ground verification.

Field Methods

In 1988, the field work had two primary objectives. First, the entire area was covered on a reconnaissance level, and striae sites located and mapped. Up to the time of writing, over 150 striae sites have been found mainly over the northern half of the peninsula. Secondly, wherever sections were found through Quaternary sediments, these were examined and described. When sections or trenches exposed glacigenic sediment, detailed sedimentological work was undertaken. Field work started in August.

Results

With field work still in progress, it is difficult to provide definitive interpretations of the results obtained so far. Preliminary plots of striae show some definite regional trends (Figure 1), generally confirming the conclusions of Hibbard (1983). Little evidence of a prevalent northerly flow is seen, with the clearest regional flow trends

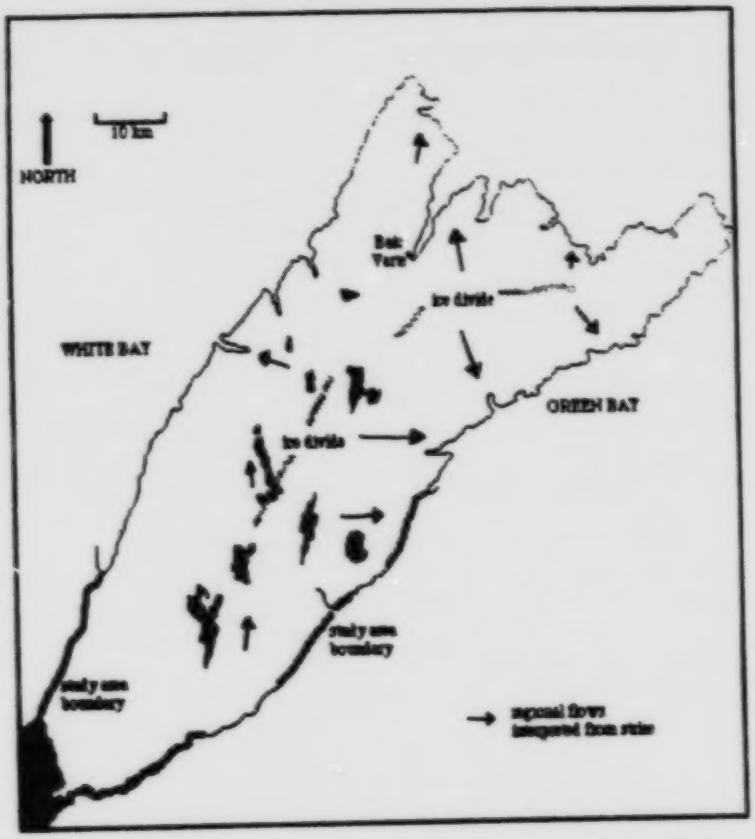

Figure 1: Ice flow over the Baie Verte Peninsula.

being from the centre of the peninsula out to the sea. The central low area of the peninsula appears to have acted as an ice divide, and another ice divide has been tentatively identified positioned south of the Rambler mine area. Striae indicating multiple flow directions are common, but apart from a few cases, do not suggest a wide divergence from strong regional trends. The influence of local topography is thought to be responsible for examples interpreted as showing major divergence, with striae resulting from a regional ice flow overprinted by later striae, usually parallel to local valley trends.

To date, only a few section/ trenches have been examined in detail. In the Flatwater Pond area, studies on diamicton exposed in trenches show a dominantly massive sediment, with the only clear structure being a sub-horizontal fissility. Clasts are mainly angular, and of local provenance. Clast orientation analysis shows very strong unimodal fabrics suggesting ice flow varying between 320° and 356°. Strong unimodal fabrics, fissility, and local clast lithology are thought to be characteristic of lodgment till (Lawson 1979, Muller 1983). Striae in the area are multidirectional, with the best example showing three sets with a clear relative age relationship. The oldest set is 0.3-0.4 cm across, 0.2-0.3 cm deep oriented at 324°, cut by grooves 1-2 cm across, 0.5 cm deep, at 310°. The youngest set consists of fine striae, 0.1 cm or less across and less than 0.1 cm deep oriented at 290°. This suggests that, although this area was affected by variable ice flow, with increasing topographic

influence during deglaciation. However, comparison with fabric data suggests, the early flow to the north and north-west was reponsible for depositing the bulk of the surface sediment.

Further Work

The rest of the field season will be spent completing striation mapping, and in further sedimentological study. Striation work will be supplemented by aerial photograph interpretation to provide an open file map of ice flow over the peninsula.

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AGGREGATE REVIEW - 1988

by

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Activities during this past summer were office orientated and related to production of 1:50,000 scale open file landform classification and aggregate resource maps for coastal Labrador, and for a possible transportation route from the Strange Lake mineral deposits eastward to the Labrador coast. Work also continued on silica-rich sands in western Newfoundland.

The coastal Labrador open-file (Open File LAB 642) contains 26 landform classification maps (3D/4,5,12, 13; 3E/5W,12; 13A/1,7-10,16; 13H/6-11,15,16W; 13J/12,13W; 13N/10,14,15; 13O/3E) and 15 aggregate maps (3D/4W,5,12; 13A/8- 10,16; 13H/6,9-11; 13J/1W,2E: 13N/10,15). The potential Strange Lake to coastal Labrador transportation route (Open File LAB 691) contains 3 landform classification maps (14D/6,7,8) and are complementary to maps No. 88-03 and 88-04 by M.J. Batterson for landform classification along western section of potential route and 5 aggregate maps (14D/5-8; 24A/8).

Landform classification maps were compiled from the interpretation of 1:50,000 scale black and white airphotos. These maps outline landforms and/or landform complexes, and special features such as glacial flow indicators. The aggregate maps depict zones of aggregate potential that were initially defined from airphotos and subsequently field checked, samples and zoned according to aggregate potential. These maps also give sample numbers, localities and type of sample collected in the field.

These two open-files also contain cumulative graphs for all granular samples collected in the field. Cumulative graphs show percentages of gravel, sand and silt/clay content and comparisons to class A and B materials used in engineering standards. Percentages of material retained in individual sieves (sieve openings of 63mm, 31.5mm, 16mm, 4mm, 2mm, 1mm, 0.5mm, 0.125mm and 0.062mm) can also be determined from these graphs. A petrographic number for the +16mm size material for each sample is also given.

Work is continuing on a comprehensive report on silica-rich sand deposits in western Newfoundland. This report primarily discuss silica-rich sand deposits with low levels of alkalies which maybe used as a raw material in cement production.

Other work in progress includes open file maps for general aggregate and landform classfication, along all transportation routes in Newfoundland and Labrador, compiled by F.T. Kirby and R.J. Ricketts between 1978-1981. These maps will be released as Open File Nfld. 1642 and contain approximately 360, 1:50,000 scale maps.

RECONNAISSANCE STUDY OF BEDROCK AGGREGATE POTENTIAL FOR INDUSTRIAL USE

by

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During the 1988 field season an evaluation of the aggregate potential of bedrock quarries from Goobies to Gander in eastern Newfoundland was undertaken. This assessment was done to determine the quality and quantity of bedrock for industrial use.

Field work consisted of road traverses along the highway and side roads; road cuts were sampled in areas where no rock quarries exist.

The field investigation for each site consisted of determining, where possible, ownership and use of each quarry. Rock type, overburden thickness, degree of weathering, geological structures, mineralization, and veining and alteration were also noted.

Petrographic analysis and petrographic numbers will be done on and assigned to all the samples collected, further Los Angeles Aberasion and Mg SO_2 soundness tests will be completed on randomly selected samples.

A total of 293 sites were visited during the present field season and 260 samples collected. Data on these sites and samples should be available by the end of 1988 or early 1989.

QUATERNARY MAPPING FOR DRIFT PROSPECTING, BURNT HILL (2D/5) AND GREAT GULL LAKE (2D/6) MAP AREA

by

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Quaternary Geology Section

Regional surficial mapping (1:50,000) in the Burnt Hill (2D/5) and Great Gull Lake (2D/6) area was completed during the 1988 field season (Figure 1). This work is designed to provide a basis for drift prospecting and is a northward extension from the area mapped during 1987 (2D/3; Proudfoot, 1987, 1988). Active mineral exploration is mainly in the eastern half of the Burnt Hill map sheet, and along the Terra Nova River on the Great Gull Lake map sheet. The study involves terrain and materials mapping, glacial flow history, sedimentology, glacial dispersion and stratigraphy. Road access to the area is limited to Highway 360 and a few adjacent woods roads. All-terrain vehicles were used on a power transmission line and on poor logging roads. Helicopter support was necessary elsewhere.

Several key areas were chosen for detailed sedimentologic and geochemical analysis.

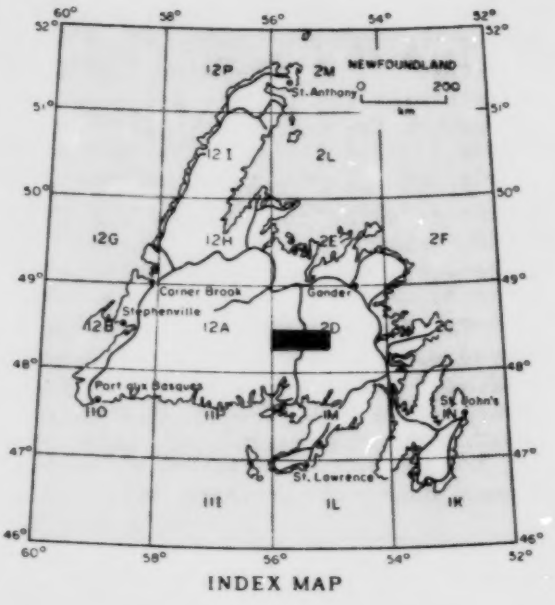

Figure 1: Map showing field survey undertaken during the 1988 field season (field survey area in black).

Geological Setting

The study area is located in central Newfoundland, midway between Bishop's Falls and Milltown. It straddles the GRUB Line and is underlain by Cambrian to Devonian aged metasedimentary, metavolcanic and ophiolitic rocks that have been intruded by Silurian to Devonian granitic rocks. Exploration for gold is focussed on the ultramafics of the Gander Group, particularly in areas where they are in fault contact with metasedimentary rocks, and in felsic volcanic rocks of the North Steady Pond Formation of the Baie d'Espoir Group (1988, pers. comm., S. Colman-Sadd). The study area also contains a significant tungsten deposit within Baie d'Espoir metasedimentary rocks (Great Gull Lake property, Falconbridge) and there are occurrences of massive sulphides within metavolcanic rocks (Colman-Sadd, 1985, Blackwood, 1982).

Regional Quaternary Geology

The predominant regional ice flow interpreted from striations on bedrock is southward (160°-170°) across the entire map area. This regional flow also produced well developed, glacially streamlined

features and transverse ridges throughout much of the central part of the area. It is likely that this was the major direction of glacial sediment transport. In the northern quarter of 2D/6, however, there is abundant striation evidence for a subsequent northeasterly flow (060°). At this time, the extent of the flow is unclear because it extended north and east of the study area. Streamlined features that are parallel to the southward flow can be traced beneath features attributed to the northeastward flow (based on airphoto interpretation, striations and till pebble fabric), suggesting that this later flow apparently did not extensively modify the landscape. This is significant because it may be that sediment transport northeastwards was relatively minor.

The surficial geology is broadly grouped into four geomorphic zones that trend northeast-southwest across the map area. The northernmost (and eastern?) parts of 2D/6 and several smaller areas in the central part of 2D/5 are covered with sand and gravel. This sediment occurs in hummocks, esker systems and dissected fans of glacial outwash origin. Much of the central part of 2D/6 and the southern part of 2D/5 are dominated by subglacially streamlined ridges trending 165°±5° that are predominantly composed of till. Ridges that are transverse to the predominant ice flow direction cover a large area on the north side of the Northwest Gander River, north and west of Coy Pond. The southern part of both sheets is predominantly covered by hummocky terrain.

Drift Exploration

This study is designed to provide base data on ice flow directions, the genesis of landforms and sediment, and distance of transport so that sediment sampling programs can be optimized and the source direction of drift anomalies more easily incerpreted. Throughout most of the area the only ice flow direction was southward (165°±5°) so that tracing of anomalies is straightforward. However, within about 10 km of the northern boundary of the map area a subsequent northeastward flow (060°) has complicated glacial dispersion so that tracing of anomaly sources is more difficult.

Within this area of northeastward flow on 2D/6, till is rare at the surface because of a blanket of glaciofluvial sediment that is generally more than 2 m thick. Sampling of this material for drift prospecting is not recommended, because it cannot be traced back to its bedrock source.

The preferred orientation of pebbles in basal till (fabric) exposed in backhoe pits, in several landform types do not agree with the ice flow direction interpreted from nearby striations on bedrock. This suggests that complete reliance on striations to interpret local ice flow direction may lead to problems.

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GENERAL PROJECTS

CORE STORAGE PROGRAM, 1988

by

A. Harris and S. Cochrane
Publications and Information Section

In 1979, the Newfoundland Department of Mines commenced a drill core collection and storage program. The objective of this on-going program is to provide well maintained and representative collections of drill core from as many drilling programs as possible, for the future use of the mineral exploration industry, government, and university geoscientists and other geotechnical professionals.

Drill Core Acquisition

During 1988 drill core acquisition continued in insular Newfoundland; a total of 418,601 m of drill core samples were added to the collection. Most of this core, 406,427 m, was acquired from the former Buchans co-tenacy of ASARCO and Abitibi-Price. All of these samples have now been moved into the core storage building in Buchans, and organized on core storage racks. Most of this work was accomplished during this past summer, and preparation of a catalogue of all drill core in the building is in progress. Another 12,174 m of core samples were delivered to our facilities for confidential storage by mineral exploration companies.

Drill Core Libraries

The Department of Mines now operates five core libraries located at St. John's, Buchans, Springdale, Pasadena and Goose Bay. The core libraries at St. John's, Pasadena, Goose Bay and Springdale all contain similarly equipped core examination laboratories which feature rock cutting equipment, a core splitter, and a stereomicroscope. These buildings share access to a magnetic susceptibility meter, a resistivity meter, an ultraviolet light and a scintillometer. The Buchans core library does not yet feature a core examination library.

The five core libraries now house a total collection of 665,401 m of drill core of which approximately 608,930 m are classified as open and are available for inspection by interested parties.

The core storage program is presently storing 56,471 m of core on a confidential basis. Requests for confidential storage are treated on an individual basis, and are generally accommodated where sufficient space is available in our core libraries, subject to the terms and conditions affecting the confidential storage of drill core samples.

Plans

The compilation of a catalogue of all core material in the Buchans library is anticipated this year, and the collection and organization of data relevant to this core material, i.e., logs, plans and sections, etc. should be completed this winter. This material will be available for inspection and examination in the Pasadena library, until an office and core examination area is added to the Buchans core library. The acquisition of a building in Baie Verte suitable for use as a core storage library is anticipated, during 1989.

GEOSCAN - THE NATIONAL DATABASE FOR GEOLOGICAL INFORMATION: THE NEWFOUNDLAND CONTRIBUTION

by

Catherine Patey and Janet Gillespie
Publications and Information Section

GEOSCAN is a computerized bibliographic database of Canadian-produced and/or Canada-related geoscience documents.

The Newfoundland Department of Mines and Energy is one of the fifteen agencies which index documents for input into this database. Our Mineral Assessment Report Library files and mineral inventory cards are the sources of our indexed records. Other agencies, e.g., the Geological Survey of Canada, also produce and index documents that concern this province.

In 1982, the National GEOSCAN Centre, which manages GEOSCAN, installed a new software system, called MINISIS, to input and retrieve the bibliographic data more effectively. In the implementation of the new system, all the old records were converted to a new format. For example, different types of keywords were moved into different fields: map types, illustrations, geological terms. Although most of the records did convert, they did not convert cleanly and completely. For example, records may be missing a title or authors and terms may have been assigned to the wrong fields. In cooperation with the National GEOSCAN Center, these older records are being corrected.

All new records are input onto the new system via batch entry and are immediately retrievable, online. To date, only indexed records for assessment files are being keyed into the system, although other types of records, in particular, those for government publications, have been coded.

Besides indexing and keying new records, new coding sheets are being produced, the authority files or thesauri used in coding are being enlarged, and the terms used are being more clearly defined.

The non-confidential records in the 150,092 GEOSCAN records from across Canada, including those concerning this province, are available through online computer searches at the Geological Survey of Canada Library in Ottawa and, in St. John's, at our Publications and Information Section. Searches are performed on a cost-recovery basis with a minimal charge of $10.00 per search topic. A moderate size search (100-200 titles) costs between $15 and $45.

As well, GEOSCAN Newfoundland and Labrador indexes, (NTS, Keywords, Authors-corporate and personal) current to February 1982, the date of the last update on the old system, are available from the Publications and Information Section. A rough computer printout index sorted by N.T.S. values, to assessment files entered into GEOSCAN from 1982 to 1984 is also available.

This year two persons joined the GEOSCAN project - a geologist and a clerk. We have prepared a NTS index to assessment files received in the Publications and Information geofiles from April 1985 to June 1988. This coming spring (1989) we intend to

have other indexes from new and revised records in the database.

We welcome suggestions for improvements and appreciate being notified of any errors or discrepancies that you may discover in the earlier indexes. This will aid us in making detailed modifications of the documents.

For further information on GEOSCAN, please contact Catherine Patey (709) 576-3159.

REVIEW OF COMPUTER UNIT ACTIVITIES FOR 1988

by

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Geochemistry and Geophysics Section

During the past year the Division has seen a steady growth in computer use among the geoscientific staff in both the micro and minicomputer areas. At the present time there are 21 IBM PC Compatibles and 1 Macintosh distributed among the various sections hosting a variety of statistical, word processing, DBMS, communications and graphics packages. As well, peripherals such as plotters, digitizers, scanners and film recording equipment have given the users new tools with which to analyze and display their data. With the hardware/software tools at hand, users can now exercise more individual control over data analysis, map layout, etc. The popular consensus among the geoscientific staff regarding computers in the workplace has been very favourable, with the major complaint being, "There are not enough micros".

The Computer Unit also maintains a Hewlett Packard 9000/560 minicomputer running the UNIX operating system. Consisting of 5 terminals, 2 tape drives (magtape and cartridge) 264 Mb of disk storage, printer and plotter, this system is used mainly for running such packages as SPSS-X, MAPPLOT, PLOTGEN and GRASP (the latter two courtesy of the U.S. Geological Survey). Other main uses include access and storage of the Mineral Occurrence Data System and long term archiving of data.

Another area that has seen increased use during the past year has been the movement of data between Micom (the word processing system), Pc, and mini environments. Data can be analysed on the mini, sent to the micro for some extra editing and then transferred over the phone lines to the Micom to be included in a report.

Major software development projects for this year include:

- Porting GRASP from the IBM environment at NLCS, to the UNIX system with enhancements made to the graphics utilities.
- Writing of an editor and utilities for the MODS data files.
- Installing and maintaining the PLOTGEN and MAPGEN packages.
- Installing a 2400 baud modem to give users dial-in access to UNIX.

It is hoped that next year will see more micro-computers in the Division for individual as well as general use. Also planned for next year is an upgrade to the mini, to increase storage capacity and throughput. A start is being made on implementing a geographical information system containing geophysical, geochemical, geological and landform data. The Unit will be assisting the Publications and Information Section change from a Micom to a PC environment for their word processing requirements as well as designing a Mineral Rights database system for the Mineral Lands and Mines Division. Another forthcoming project is to design and implement an inventory system for the laboratory to keep track of samples sent for analysis.

More detailed information concerning the hardware and software that is available in the Mineral Development Division can be supplied by the Computer Unit upon request.

REPORT OF THE GEOCHEMICAL LABORATORY FOR 1988

by

H.A. Wagenbauer
Geochemistry and Geophysics Section

The number of determinations performed by the Geochemical Laboratory from September 1, 1987 to August 31, 1988 is summarized in Tables 1 and 2. The total is 12% less than in the same period last year, due to a decreased demand as the end of the current Mineral Development Agreement approaches. There has also been a substantial increase in samples prepared and sent for outside analysis to commercial laboratories - mainly for gold and associated elements by multi- element neutron activation analysis. The analytical work on the samples submitted during the 1987 field season has been completed, and three laboratory assistants employed on a temporary basis have been laid off due to the decreased demand for analytical work. Considerable work has been done to expand the number of elements analysed by ICP from 20 to 48.

Table 1. Summary of output from the Geochemical Laboratory for the period September 1, 1987 to August 21, 1988.

Geochemical analysis of soil, till, lake and stream sediments	30849
Silicate analysis	
Major Elements A.A.	15472
ICP	3237
Photometric	753
Classical	5505
Potentiometric	2669
Trace Elements A.A.	28941
ICP	61976
Miscellaneous Analysis, Assays, H_2O^-, H_2O^+, CO_2, S	1863
Total	151265
Sample Preparation	
Rock samples crushed	1213
Rock samples pulverized	1811
Lake stream soil samples sieved	1891
Samples split, samples shipped for outside analysis, samples recombined	15062
Samples weighed for outside analysis	15252

Table 2. Summary of methods used and detection limits achieved routinely for trace elements in silicate rocks by atomic absorption spectrophotometry (AAS) and by inductively coupled plasma emmision spectrometry (ICP).

Element	Digestion	Detection Limit[1] by AAS	(g/t by ICP)
Ag	HF-HCl-HClO4	0.1	
Ba	HF-HCl-HClO4	10	2
Be	HF-HCl-HClO4	0.1	0.1
Bi	HF-HCl-HClO4		2
Cd	HF-HCl-HClO4	0.1	
Ce	HF-HCl-HClO4		2
Co	HF-HCl-HClO4	2	
Cr	HF-HCl-HClO4	2	
	LiBO4 fusion		10
Cu	HF-HCl-HClO4	2	
Ga	HF-HCl-HClO4		2
La	HF-HCl-HClO4		2
Li	HF-HCl-HClO4	0.1	0.1
Mo	HF-HCl-HClO4	2	
Mn	HF-HCl-HClO4	5	5
Nb	HF-HCl-HClO4		2
Ni	HF-HCl-HClO4	2	
P	HF-HCl-HClO4		5
Pb	HF-HCl-HClO4	2	
Rb	HF-HCl-HClO4	2	
Sr	HF-HCl-HClO4	2	2
Th	HF-HCl-HClO4		2
Ti	HF-HCl-HClO4	50	2
V	HF-HCl-HClO4	5	2
Y	HF-HCl-HClO4		2
Zn	HF-HCl-HClO4	2	
Zr	LiBO4 fusion		5

1 The detection limit may be higher in some rocks due to matrix effects.

THE EMPLACEMENT AND PETROGENESIS OF PROTEROZOIC DYKE SWARMS

by

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